1970

A Comparison of a Low Protein Diet Plus Added Methionine with a Normal Diet for Three Strains of Laying Hens in Various Environments

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A COMPARISON OF A LOW PROTEIN DIET PLUS ADDED METHIONINE WITH A NORMAL DIET FOR THREE STRAINS OF LAYING HENS IN VARIOUS ENVIRONMENTS

BY

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A thesis submitted
in partial fulfillment of the requirements for the
degree Master of Science, Major in
Poultry Science, South Dakota
State University

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Adviser   Date

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ACKNOWLEDGMENTS

The author wishes to express his most sincere appreciation to Professor C. Wendell Carlson, the thesis adviser, for the kind assistance and guidance provided throughout the conduction of this research and the preparation of this thesis.

The guidance received from Professor William Kohlmeyer, former head of the Poultry Science Department at South Dakota State University, during the author's years of undergraduate study will never be forgotten.

The assistance of Mr. Curtis Holmquist, superintendent of the South Dakota State University Poultry Research Center, in conducting the research is also gratefully appreciated.

The author owes a special debt of gratitude to his wife, Karen Joan Muller, for assistance in the preparation of this thesis.

The author extends special appreciation to Dr. W. L. Tucker for conducting the statistical analyses.

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INTRODUCTION

The protein requirement of the laying hen encompasses a problem of great importance to the nutritionist. With the discovery of amino acids, which are commonly referred to as "the building blocks of protein," it was soon evident that the fowl had a requirement primarily for amino acids, not protein.

It has been difficult to establish the exact amino acid requirements of each species and age group. To overcome this difficulty, feed formulae for laying hens as well as other groups of fowl have been designed to provide a surplus of protein and thus amino acids from a wide variety of sources. In general, this practice has met with success.

Today, however, we are faced with economic restraints which compel the feed manufacturer to exclude all unnecessary ingredients from rations. In view of the high cost of protein supplementation, it has been deemed necessary to restrict protein levels to the bare minimum essential for the most efficient production.

If protein supplements can be fortified with amino acids from a synthetic source to balance the amino acid content of the feed to the amino acid requirement of the hen, it may be possible to reduce the cost of egg production.

Soybean meal, the most commonly used protein supplement in laying hen diets, is deficient in the amino acid methionine. These experiments were undertaken to compare a typical corn-soy type diet which was considered adequate in both protein and methionine to a similar corn-soy type diet which was lower in protein but supplemented with synthetic methionine.

REVIEW OF LITERATURE

The Discovery of Methionine

The amino acid methionine was discovered in 1921 by Mueller (1923), a bacteriologist. Mueller noted that certain protein hydrolysates stimulated the growth of hemolytic streptococcus while others failed to do so. In a casein hydrolysate, which had supplied the necessary growth factor, Mueller found a crude fraction which contained sulfur other than cystine.

Barger and Coyne (1928) synthesized a compound which had a structure identical to the natural methionine. Both D and L forms were shown to be present.

Although methionine was one of the more recently discovered amino acids, it has been the subject of far more research by avian scientists than any other amino acid. According to Ewing (1963), this is a result of the changeover from animal proteins to soybean and other plant proteins for protein supplementation during the 1930's.

Essentiality of Methionine

Methionine was first shown to be indispensable in rat diets in a series of papers involving Rose *et al.* (1936), Rose (1937), Womack, Kemmerer and Rose (1937) and Womack and Rose (1941). These workers established the essentiality of methionine in the diet and the dispensability of cystine for the rat.

The relationship between choline, homocystine and methionine was worked out by du Vigneaud et al. (1939). They showed that in the presence of choline homocystine is capable of replacing methionine in the diet of the rat. It was found that on a cystine deficient diet body cystine was formed from methionine and that on a suboptimal methionine diet cystine included in the diet has a methionine sparing action.

It was shown by Klose and Almquist (1941), Grau and Almquist (1943) and Almquist and Grau (1944) that the relationships observed with the rat between cystine and methionine and between choline, homocystine and methionine were also applicable to the chick.

Supplementation of Soybean Protein

Mitchell and Smuts (1932) were the first workers to attempt supplementation of soybean meal with sulfur containing amino acids. They showed that the growth of rats on a ration containing raw soybean meal could be improved by the addition of L(-) cystine. Shrewsbury and Bratzler (1933) confirmed this observation. Hayward, Steenbock and Bohstedt (1936) demonstrated that a rat diet containing heated soybean meal could be likewise improved by the inclusion of L(-) cystine.

It was not until 1941 that the sulfur containing amino acids were used to supplement soybean meal in the diet of the chick.

Hayward and Hafner (1941) investigated cystine and methionine as supplements to raw and cooked soybeans for rats and chicks. It was found that the protein of raw soybeans was greatly improved by the addition of 0.3% L(-) cystine and even more so by the addition of 0.3% D-L methionine and that the protein of cooked soybeans was equally improved by the addition of 0.3% L(-) cystine or 0.3% D-L methionine. Almquist et al. (1942) reported that the addition of choline to a synthetic raw soybean meal diet produced little or no increase in the rate of gain, and that the addition of D-L methionine resulted in a rate of gain which was comparable to that obtained on practical diets of the same total crude protein. They concluded that the lack of methionine was the principal growth limiting factor in raw soybean protein and that heated soybean protein is slightly deficient in methionine for the chick at the 20% protein level.

A series of papers by Berry et al. (1943a,b) and other authors put forth evidence to show that choline and methionine may be used interchangeably as supplements to a practical soybean meal starter diet.

Bird and Mattingly (1945) refuted this idea with evidence that methionine and choline could not be used interchangeably as supplements to a practical soybean meal type diet. Clandinin et al. (1946) confirmed this observation when they found that three out of four soybean meals tested were not improved by choline addition, whereas all four meals were improved by methionine supplementation.

Protein and Methionine in Laying Hen Diets

After establishment of the need for methionine in the supplementation of corn-soy type chick starter diets, research was extended to layer diets. In establishing the requirement of the laying hen for supplemental methionine, the protein requirement of the hen, the protein-to-calorie ratio of the ration and the amino acid deficiencies of the types of feeds being fed must be considered. Such factors as egg production, egg size, body weight and influences on health and physical condition must be evaluated.

Considerable research has been conducted to determine the exact protein requirement of the laying hen. Several groups of workers (Reid, Quisenberry and Couch, 1951; Milton and Ingram, 1957; Hochreich et al., 1958) have reported the diet must contain at least 17% protein in order to attain maximum production. Heuser et al. (1945) indicated 15% protein was sufficient, while Thornton, Blaylock and Moreng (1967) reported 11% protein was barely adequate for maximum production. The National Research Council (N.R.C., 1966) currently recommends 15% protein.

In establishing protein requirements for laying hens, several workers have noted distinct differences between different strains of birds. Moreng et al. (1964) placed four major strains (arbitrarily called A, B, C and D) of chickens on diets with three different levels of protein (13, 15 and 17%). It was found that significant differences existed with specific characteristics measured. Strain differences were found to exist in egg production and Haugh unit values. Differences in many instances were noted for both egg weight and shell thickness and were isolated to a specific dietary level of protein and a specific strain. Strain B showed its highest level of egg production on the 13 and 15% protein diets with its performance on the 17% diet inferior to strains A, C and D. Strains A and C gave the poorest production when fed the 13% protein diet.

Harms, Damron and Waldroup (1966a) noted large differences between the protein requirement of several strains of egg type pullets. Hens were fed four different levels of protein (11, 13, 15 and 17%) over a 280-day laying period. It appeared that the Cornell random-bred had the highest protein requirement followed by the Kimber 137, the HyLine 934 C, the Kimber 155 and the HyLine 934 H with the New Hampshire breed having the lowest requirement. The New Hampshire breed performed remarkably well on the 11 and 13% protein diets while the Cornell random-bred performed best on the 17% protein diet.

It is evident that differences exist between strains in their protein requirement for satisfactory production when protein requirements are expressed on a percentage basis. Many researchers have expressed the opinion that protein requirements should be established on the basis of grams of protein per hen-day.

Balloun and Speers (1969) reported that data from three experiments disclosed significant variation in the protein requirements among five strains whether the protein requirements were expressed as a percentage of the diet or on a daily intake basis.

In general, it was found that these requirements were directly related to the body weight of the strains tested. For HyLines a 16% protein diet which supplied 14.9 g of protein daily was adequate for maintenance of highest egg production and best feed conversion efficiency over a 36 week period. The larger Ames Incross strains performed satisfactorily on the 14% protein diets. However, average daily protein consumption was 16 g. Three experimental Leghorn strains required from 10 g (light weight strain) to 18 g (heavy weight strain) of protein daily for optimum performance.

Another factor involved in the protein requirement of laying hens is the protein-to-calorie ratio of the diet. Over the past several years, a steady trend toward the use of rations of progressively higher energy values has developed. This trend started with broilers and extended to layers. According to Ewing (1963), this trend is due to the increase in efficiency of production which accompanies an increase in energy concentration.

When the energy content of a ration is increased, a smaller amount of feed is consumed because the hen eats to meet her needs for energy. Thus, a relatively fixed quantity of protein must be supplied by a smaller amount of feed. This also applies to the requirement for amino acids such as methionine. Harms, Damron and Waldroup (1966b) noted that a decrease of 22 kilocalories of productive energy per kilogram of diet resulted in a 1% increase in the amount of feed consumed per hen per day. This change in feed intake resulted in a 1% change in the methionine and sulfur amino acid requirements.

Protein and amino acid requirements were at one time given as a percent of the ration without any specification as to the energy content of the ration. The National Research Council now specifies protein and amino acid levels as percentages of the diet and specifies the particular level of metabolizable energy with which these values are standardized. The N.R.C. (1966) presently recommends that layers receive 15% protein in a ration containing 2850 kilocalories of metabolizable energy (ME) per kilogram.

Ingram _et al_. (1951) found that egg production was lowered by a methionine deficiency and concluded that the requirement for the laying hen was not more than 0.38% of the diet in the presence of 0.25% cystine. Leong and McGinnis (1952) stated that the level of methionine required for supporting maximum egg production, body weight gain and egg size appeared to be approximately 0.28% in the presence of 0.25% cystine.

Soybean meal, commonly used as a protein supplement to corn for laying hen diets, corrects the lysine deficiency of corn. However, the soybean meal magnifies the methionine deficiency of corn unless large quantities of soybean meal are added to furnish adequate methionine and surpluses of the other amino acids. Bray (1968) used varying ratios of corn and soybean meal supplemented with amino acids in a diet containing 8.5% protein. The response to methionine increased progressively as soybean replaced corn protein. A mixture of tryptophan, lysine, isoleucine and valine gave decreasing responses as soybean protein replaced corn protein.

According to calculations by Titus (1955), methionine is indicated to be the first limiting amino acid in a corn-soybean meal type laying hen diet. However, reports of Reid et al. (1951), Mehring, Titus and Waddell (1954) and Heywang (1956) indicate no response from supplementing such diets with methionine. Bradley and Quisenberry (1961) noted a slight nonsignificant decrease in egg production of birds being fed 16% protein and 18% protein diets supplemented with lysine and/or methionine. An increase in production was observed for birds being fed a 14% protein diet.

Carlson and Guenthner (1969) stated that calculations demonstrate that, when methionine supplementation has not shown a response in the past either in egg numbers, egg weight or feed conversion, calculated protein intake was generally in excess of 16 g per hen per day with a methionine intake in excess of 300 mg per hen per day.

Harms, Douglas and Waldroup (1962) supplemented diets with 0.075% methionine hydroxy analogue calcium (MHA) and significantly improved performance in two of three experiments. The first experiment, conducted in cages, showed a 9.6% average increase in the rate of lay and an improvement in feed conversion for a 280-day period when birds were fed protein levels of 14.7, 15.7 and 16.7% with and without methionine supplementation.

The second experiment, conducted with floor layers, showed no significant differences. The third experiment, again conducted in cages, showed a response to methionine supplementation during the latter 4 months of the laying period. Evidence was presented during these trials that the hen will overconsume on either protein or energy in an attempt to meet her need for the other nutrient.

Carlson and Guenthner (1969) conducted four experiments over a period of four years evaluating protein, methionine and lysine in typical corn-soy diets for laying hens. The experiments, conducted in a cold wall house, were summarized into 3 periods on the basis of similar environmental temperature.

In the first experiment, 16% protein diets were supplemented with 0.1% methionine, 0.1% lysine and methionine plus lysine. No significant differences were observed. The protein intake exceeded 17 g per hen per day while the methionine intake averaged 320 mg or more per hen per day.

In the second experiment, the birds were started on a 16% protein diet in the first period (August to November) and were switched to a 14% protein diet during the second (December to February) and third (March to June) periods. The 14% protein diets were supplemented with methionine and methionine plus lysine. No significant differences were observed in the numbers of eggs produced in the first period. Egg size was improved by methionine supplementation. During the third period, the production fell markedly in the hens receiving the 14% protein basal without supplementation. The hens in this group consumed less than 16 g of protein and under 300 mg of methionine daily.

In the third experiment, it was found that a 14% protein diet supplemented with 0.1% methionine produced significantly more eggs than the 16% protein control diet.

In the fourth experiment, it was found that hens could maintain maximum production on a 14% protein diet plus methionine, thus receiving 15 g of methionine supplemented protein per day.

It was concluded from these experiments that the 14% protein diet supplemented with methionine was adequate under the conditions tested while 16% protein would be required without the methionine supplementation. Calculations showed 17 g of protein per hen per day to be adequate without methionine supplementation, whereas 15 g of methionine supplemented protein was adequate for maximum production, egg size and feed efficiency. The methionine requirement was believed to be somewhat in excess of 300 mg per hen per day during the first four months of production. This requirement was believed to have dropped to the 300 mg level during the latter periods as no significant results were obtained from its addition to diets at this level during these periods.

The N.R.C. (1966) indicates that hens require a diet containing 0.28% methionine and 0.25% cystine. Harms and Damron (1969) confirmed the N.R.C. data showing that the methionine requirement for maximum egg production is not in excess of 0.28% in a diet containing 2850 kilocalories of ME per kg of feed, provided that at least 0.23% cystine is present.

Utilization of Different Methionine Sources

Synthetic methionine is available as either the D(-) or L(-) isomer, as D-L methionine or as methionine hydroxy analogue calcium (MHA-Ca). Grau and Almquist (1943) reported equal utilization of the D(-) and L(-) isomers of methionine by chickens. Bruggemann, Drepper and Zucker (1962) reported the D(-) isomer to be inferior to the L(-) isomer in purified diets. Gordon and Sizer (1955), using S^{35} labeled MHA-Ca, L(-) methionine and D-L methionine, reported greater incorporation of MHA-Ca and L(-) methionine into chick liver protein than was found for D-L methionine. Gutteridge and Lewis (1964) found D(-) methionine to be used more efficiently than L(-) methionine in supplementing raw soybean diets.

Smith (1966) tested 3 sources of methionine in semi-purified and purified basal diets fed to growing chicks. The L(-) methionine was more efficiently utilized than the D-L form when tested in crystalline amino acid diets. D-L methionine in turn was superior to equimolar amounts of methionine hydroxy analogue. Semi-purified diets gave somewhat similar results.

Tipton, Dilworth and Day (1966) conducted two experiments in which graded levels of the D(-) and L(-) isomers of methionine were added along with D-L methionine and MHA-Ca in methionine deficient basal chick diets containing natural protein as the principal source of amino acids. The relative order of biological effectiveness (best to poorest) was D(-) methionine, D-L methionine, L(-) methionine and MHA-Ca.

It appears as if MHA-Ca is the most inefficiently used source of supplementary dietary methionine in methionine deficient diets. The relative value of D(-), L(-) and D-L methionine varies under different feeding conditions. It is doubtful if these differences are great enough to be of major significance in most laying hen diets.

EXPERIMENTAL PROCEDURES

Two experiments were conducted over a 2 year period at the newly constructed Poultry Research Center at South Dakota State University. Experiment 1 lasted 11 months, beginning in October, 1968, and ending in August, 1969. Experiment 2 began in October, 1969, and ended in March, 1970.

Experiment 1

Two strains of laying hens, a commercial hybrid, DeKalb 131, and Cornell Control Single Comb White Leghorn stock obtained from the Regional Poultry Breeding Laboratory, West Lafayette, Indiana, were used in this study. The DeKalb chickens were purchased from a commercial hatchery as day-old chicks in May, 1968, while the Regional Control chickens were hatched at the SDSU Poultry Research Center, also in May, 1968.

All chickens were reared in confinement in the same brooder house on a crushed corn cob litter after an initial 2 weeks in a battery brooder. They were vaccinated with killed virus vaccine for Newcastle Disease at one day of age and at the time of housing. The birds were fed a starter diet through 8 weeks of age and a high fiber grower diet from 8 through 20 weeks of age, both of which are recommended by South Dakota State University (appendix table 4).

In September, the chickens were transferred to a new slat floor environment house. The house consisted of three separate windowless chambers (referred to as North, Middle and South). Each chamber contained four 10 foot by 14 foot pens which were numbered from 1 to 4, 5 to 8 and 9 to 12 for each respective chamber (appendix table 5). All pens had wood lath slat floors. Due to a failure on the part of the contractor to meet state electrical specifications, no chickens were placed in pen 1 in the North chamber during experiment 1. Pen 2 contained chickens which were not included in this experiment.

Each chamber had a ventilation system independent of the other chambers (appendix table 6). The North and Middle chambers had identical ventilation systems which consisted of a large exposed fan and a small enclosed fan on one wall opposing fresh air inlets on the opposite wall. The ceiling in each of these chambers had fresh air inlets for winter use. The small enclosed fan was equipped with a damper to restrict air flow as necessary.

The South chamber had exposed rafters with the roof of the building serving as the chamber's ceiling. It was equipped with a horizontal ventilator at the peak of the roof (ridge inlet) and two reversible fans opposing each other on opposite walls of the building (appendix table 6). Both of these fans were also enclosed in boxes equipped with dampers.

Eight hundred twenty-nine DeKalb pullets were selected at random and assigned on the west side of the aisle to 2 pens in each of the 3 chambers while 616 Regional Control pullets were selected at random and were assigned on the east side of the aisle to 2 pens in each of the Middle and South chambers. Six males were also placed in each pen of Regional Controls. The pens had a population density of approximately one bird per square foot.

The chickens were placed on typical corn-soy diets on October 1 at approximately 20 weeks of age. Five pens were placed on Diet 232, a 14% protein corn-soy type diet supplemented with 0.1% methionine (MHA)[1]; and 5 pens were placed on Diet 231, a 16% protein corn-soy type diet without methionine supplementation. Each diet was assigned to 1 pen of DeKalb chickens and 1 pen of Regional Control chickens in each chamber with the exception of the North chamber which did not contain Regional Control birds.

The thermostats for all fans were set to maintain the temperature of each chamber at 55° F. The environments in the 3 chambers were therefore considered to be nearly identical. Thus, the experimental design consisted of 3 replicates of 2 strains and 2 diets within each strain with the exception of one strain missing in the one replicate. The treatments used in experiment 1 are listed in table 1.

The corn to soybean meal ratios of the diets were altered slightly to give the correct protein level whenever new sources of these ingredients were purchased. The diets were for all practical purposes isocaloric. The compositions of the diets fed and the corn to soybean ratios used are given in appendix tables 1 and 2. Complete calculated chemical analyses of the diets are shown in appendix table 3.

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[1]Methionine hydroxy analogue calcium, Monsanto Company, St. Louis, Missouri.

TABLE 1. TREATMENTS DURING EXPERIMENT 1 IN THE ENVIRONMENT HOUSE

Pen	Treatment number[a]	Type of bird[b]	Number of birds	Diet[c]	Percent protein
3	311	DeKalb	144	232	14
4	312	DeKalb	139	231	16
5	222	Regional Control	161	231	16
6	221	Regional Control	161	232	14
7	211	DeKalb	135	232	14
8	212	DeKalb	139	231	16
9	122	Regional Control	160	231	16
10	121	Regional Control	157	232	14
11	111	DeKalb	140	232	14
12	112	DeKalb	142	231	16

[a] The treatment number is coded. The first number is the rep number, the second, the strain, 1 = DeKalb, 2 = Regional Control, the third, the diet, 1 = Diet 232 and 2 = Diet 231.

[b] DeKalb 131 and Cornell Regional Control Single Comb White Leghorn.

[c] Diet 231 was a typical corn-soy diet containing 16% protein. Diet 232 was a typical corn-soy diet containing 14% protein supplemented with 0.1% methionine hydroxy analogue calcium (MHA).

A cage layer trial was added to the experiment on December 1, 1968. Sixty-seven DeKalb 131 layers were placed on Diet 231 and 65 were placed on Diet 232. The layers were reared under the same conditions as the layers in the slat floor environment house but were housed in 16 inch x 18 inch cages during September, 1968. The ventilation system in the cage house was of the slot intake type similar to that of the slat floor environment house. Each diet was fed to 3 replicates of 6 cages of birds. Diet 232 (14% protein) was fed to replicates 63, 64 and 65 on the east side of the aisle while Diet 231 (16% protein) was fed to replicates 83, 84 and 85 on the west side of the aisle. These layers had been previously maintained on a

16% protein diet during October and November. The data for these two months are not included in this thesis.

Each pen of floor layers had two feeders which were each 6 feet long giving 24 linear feet of feeder space per pen. All layers were fed ad libitum. Water was provided through a cluster of three "Hart" cups for each pen of floor layers while one "Hart" cup was between each 2 cages of cage layers.

Artificial illumination was provided for 12 continuous hours daily from October until May 1. The amount of light received daily was then increased by 1/2 hour per week until the birds received the maximum day length of 16 hours on July 1.

Monthly records for percent hen-day egg production, feed consumed per bird per day, feed efficiency, average egg weight, Haugh units, percent mortality and cause of mortality were recorded for each pen of floor layers. Fifty eggs from each pen of floor layers were weighed one day each week and these figures were averaged for the average monthly egg weight. For Haugh units (interior egg quality) and shell thickness, 25 eggs from each pen of floor layers were broken during the last week of each month. Haugh units were calculated by procedures outlined by Card and Nesheim (1966). Shell thicknesses were measured with a micrometer.

Monthly hen-day egg production records for each cage of cage layers were recorded. However, monthly feed consumption, feed efficiency, average egg weight, Haugh units, mortality and cause of mortality were recorded for the sum of all three replicates of each treatment.

The data, recorded on a monthly basis, were summarized into periods on the basis of similar environmental temperature. Period I included the months of October and November; Period II, December through February; Period III, March through May and Period IV, June through August.

Individual bird weights to the nearest 100 g were recorded in October at the beginning of the experiment and again in May. At the termination of the experiment, pen weights were obtained for all birds.

Experiment 2

DeKalb 151 layers were used exclusively in experiment 2. All pullets were grown under the same management regime as experiment 1.

During October, the chickens were transferred to three different buildings at 20 weeks of age. The 12 pens of the slat floor environment house each contained 140 chickens (1 chicken per square foot). Two pens, containing 140 chickens each, remained in the brooder house on floor litter. Twenty-four cages in one row of the cage house were filled with 6 birds each. Each cage measured 18 inches by 24 inches. The pens in the slat floor environment house were numbered from 1 to 12 as in experiment 1, and the 2 pens in the brooder house were numbered B1 and B2. A round feeder, in addition to the feeders used in experiment 1, was placed in each pen.

Two pens in each chamber of the environment house were placed on Diet 231 and two pens were placed on Diet 232. Diets 231 and 232 were similar to Diets 231 and 232 used in experiment 1 with the exception that both diets were isocaloric containing 3000 kilocalories per kilogram of diet. The ratios of corn, soybean meal and yellow grease were altered whenever new ingredients were purchased. The compositions of the diets fed and the ratios of the ingredients used are given in appendix tables 1 and 2. Calculated nutrient analyses are shown in appendix table 3.

A furnace-air conditioner combination was installed in the North chamber of the environment house. Unlike experiment 1, the temperatures in the three chambers were not identical. The temperature in the North chamber was thermostatically set at 60° F., the Middle, 45 and the South, 50. The experiment, using 3 chambers (temperatures) with 2 diets in each, had 2 replicates of each treatment at its initiation. Table 2 lists the treatments utilized in experiment 2.

Pen B1 in the brooder house received Diet 231 while pen B2 received Diet 232. This building also received supplemental heat which was thermostatically controlled at 55° F.

Each replicate of caged layers consisted of 4 cages per feeder tray. The odd-numbered trays, 101 to 107, received Diet 231, and the even-numbered trays, 100 to 106, received Diet 232.

TABLE 2. TREATMENTS DURING EXPERIMENT 2 (EXPERIMENTS 2A AND 2B) IN THE ENVIRONMENT HOUSE[a]

Pen	Treatment number[b]	Section (temp)	Diet[c]	Protein	Floor
1	111	North (60)	231	16	Slat
2	122	North (60)	232	14	Litter
3	112	North (60)	231	16	Litter
4	121	North (60)	232	14	Slat
5	211	Middle (45)	231	16	Slat
6	222	Middle (45)	232	14	Litter
7	212	Middle (45)	231	16	Litter
8	221	Middle (45)	232	14	Slat
9	311	South (50)	231	16	Slat
10	322	South (50)	232	14	Litter
11	312	South (50)	231	16	Litter
12	321	South (50)	232	14	Slat

[a] All 12 pens were on slat floors from October until January. The data from November and December are included in experiment 2A. Six pens were transferred to floor litter during January and 6 remained on slats. The data from February and March are included in experiment 2B.

[b] The treatment number is coded. The first number is the section number (temperature), 1 = North, 2 = Middle, 3 = South; the second, the diet number, 1 = Diet 231, 2 = Diet 232; the third, the floor number, 1 = Slat and 2 = Litter.

[c] Diet 231 was a typical corn-soy diet containing 16% protein. Diet 232 was a typical corn-soy diet containing 14% protein supplemented with 0.1% methionine hydroxy analogue calcium (MHA).

In pens 1 to 12, B1 and B2, monthly records identical to those of experiment 1 were recorded. For caged layers, egg production and bird weight data were recorded for each cage while all other record criteria were recorded for each feeder tray.

At 20 weeks of age, artificial illumination was provided for 12 continuous hours daily. This was increased by 1/2 hour per week until a maximum day length of 14 hours was provided at 24 weeks of age.

The data collected during October are not included in this thesis. The hens laid very few eggs during October. The data reported are from records beginning in November when the layers were approximately 22 weeks old.

During January, the slat floors were removed from 6 of the 12 pens in the environment house. The layers in these 6 pens were placed on a crushed corn cob floor litter. The data collected during the month of January are not included in this thesis due to the fact that the slats were removed over a two week period when the weather would permit.

The data for November and December are reported in the tables as experiment 2A, while the data for February and March when both slat floors and litter floors were tested in the environment house are reported as experiment 2B. Although no treatments were changed between these two monthly periods, the data for the caged layers and for pens B1 and B2 are recorded as experiments 2A and 2B for November-December and February-March, respectively.

STATISTICAL PROCEDURES

Experiment 1

All data from the environment house were subjected to the least squares analysis of variance (Steel and Torrie, 1960). Mortality data were first transformed by calculating the square root of (X + 1/2). The analysis of variance was then conducted on the transformed data.

The egg production records of the caged layers were subjected to the analysis of variance (Steel and Torrie, 1960).

Experiment 2

All data from the environment house layers were subjected to the least squares analysis of variance (Steel and Torrie, 1960). Mortality data were again transformed by calculating the square root of (X + 1/2). Separate analyses were conducted for experiments 2A and 2B. No statistical analyses were performed on the data from pens B1 and B2 in the brooder house.

The data from the caged layers were also subjected to the least squares analysis of variance. Separate analyses were conducted for experiments 2A and 2B. Data from each cage of layers were analyzed for percent hen-day egg production and body weight. Since few caged layers died, mortality data were not analyzed for either experiment 2A or 2B. Data from each feeder tray (rep) were analyzed for the remaining measurements recorded.

RESULTS AND DISCUSSION

The results of experiments 1 and 2 will be discussed individually in this section and will be discussed together later in the summary.

Experiment 1

The data from both the environment house layers and the caged layers will be presented simultaneously. The data for individual pens are presented in the appendix while the means of the treatments used and the analyses of variance will be presented in the text of this section.

Egg Production

The treatment means of the percent hen-day egg production for the environment house layers are presented in table 3. The performance of each replicate of cage layers is shown in table 4.

The only significant difference recorded for the environment house layers was a difference between periods ($P<.05$). This difference was attributed to the lower egg production during Period I while the hens were maturing.

During all periods, the hens receiving the 16% protein diet (Diet 231) produced eggs at a rate which was slightly superior to the hens receiving the 14% protein diet (Diet 232). Note that the overall average hen-day egg production for Diet 231 was 43.92% while that for Diet 232 was 41.25%, a 2.67% advantage for the 16% protein diet.

TABLE 3. AVERAGE PERCENT HEN-DAY EGG PRODUCTION FOR THE ENVIRONMENT HOUSE LAYERS DURING EXPERIMENT 1[a,b]

	Period				
	I	II	III	IV	Overall
Period	39.49	45.05	42.29	42.48	42.58
Diet 231	41.59	46.81	43.20	43.29	43.92
Diet 232	37.40	43.29	41.37	41.67	41.25
DeKalb	44.82	49.24	44.47	43.01	45.43
Regional Control	31.51	38.76	39.02	41.70	38.31

Analysis of Variance[c,d]

Source	df	MS
P	3	51.84*
S	1	365.99
P X S	3	55.02
D	1	131.98
P X D	3	4.01
S X D	1	46.95
P X S X D	3	12.96
R	2	19.82
P X R	6	6.04
S X R	1	15.51
D X R	2	58.34
P X D X R	6	36.78
Error	7	4.27

[a] Period I includes the months of October and November; Period II, December-February; Period III, March-May, Period IV, June-August.

[b] Data for each of the 12 pens are presented in the appendix.

[c] Abbreviations used in analysis of variance tables for environment house layers during experiment 1: P = Period, S = Strain and D = Diet.

[d] Levels of significance used throughout experiments 1 and 2.

* Significantly different ($P<.05$).

** Highly significantly different ($P<.01$).

*** Very highly significantly different ($P<.005$).

TABLE 4. AVERAGE PERCENT HEN-DAY EGG PRODUCTION FOR EACH REPLICATE OF CAGE LAYERS, EXPERIMENT 1[a]

Diet	Rep	Period II	Period III	Period IV	Overall
231	1	78.02	69.79	67.25	71.69
	2	76.40	73.06	67.07	72.18
	3	76.83	64.89	60.44	67.39
	Avg	77.08	69.25	64.92	70.42
232	1	70.77	61.96	57.87	63.53
	2	70.76	60.02	58.51	63.10
	3	57.56	51.61	47.23	52.13
	Avg	66.36	57.86	54.54	59.59
Period avg		71.72	63.56	59.73	65.00

Analysis of Variance[b]

Source	df	MS
R	2	741.83*
D	1	3166.48**
D X R	2	133.94
C	5	277.31
R X C	10	141.97
D X C	5	369.20
D X R X C	10	282.61
P	2	1351.23**
R X P	4	5.92
D X P	2	2.34
D X R X P	4	39.66
C X P	10	12.59
R X C X P	20	39.48
D X C X P	10	55.73
Error	20	50.91

[a] Each replicate consisted of 6 cages containing 4 birds in each.
[b] Abbreviations are: R = Rep, D = Diet, C = Cage and P = Period.

The DeKalb hens laid eggs at a higher rate than the Regional Control hens during all periods. While the Regional Control hens had an overall average hen-day egg production of 38.81%, the DeKalb hens averaged 45.53%. The fact that neither the differences between protein levels nor strains were significant was attributed to the small number of replicates in the trial and the resulting limited degrees of freedom.

Caged layers fed Diet 231 averaged 70.42% hen-day egg production while those receiving Diet 232 averaged 59.59%, a 10.83% advantage for the 16% protein diet. This difference, as well as a period difference, was found to be highly significant ($P<.01$). A significant difference ($P<.05$) occurred among replicates. It should be noted that the caged layers were started on Diets 231 and 232 at the beginning of Period II. Thus, the overall percent hen-day egg production figures (70.42% and 59.59%) do not include the first two months of production when the hens were beginning to lay eggs. The data for the environment house layers include the Period I production.

The egg production data, particularly the caged layer data, show that the 14% protein corn-soy type diet supplemented with 0.1% methionine did not support as high a rate of egg production as the 16% protein corn-soy type diet.

Feed Consumption

Feed consumption data presented in table 5 showed a highly significant difference ($P<.01$) among periods. This was attributed

TABLE 5. GRAMS OF FEED CONSUMED PER HEN-DAY DURING EXPERIMENT 1

	Period				
	I	II	III	IV	Overall
	Environment House				
Period	101.0	114.2	134.6	119.2	118.7
Diet 231	99.9	113.0	131.7	115.3	116.2
Diet 232	102.2	115.3	137.6	123.0	121.2
DeKalb	103.0	113.5	129.4	113.0	116.0
Regional Control	97.8	115.3	142.4	128.7	123.2
	Cage Layers				
Diet 231	--	117.1	121.7	104.9	114.4
Diet 232	--	120.3	121.2	112.6	118.0

Analysis of Variance[a]

Source	df	MS
P	3	1672.90**
S	1	154.00
P X S	3	180.26**
D	1	42.01
P X D	3	18.07
S X D	1	0.08
P X S X D	3	361.54**
R	2	132.11
P X R	6	12.59
S X R	1	0.60
D X R	2	188.09
P X D X R	6	100.63
Error	7	1.91

[a] Analysis of variance tables for experiment 1 are for the data from the environment house only.

to the low feed consumption (101 g) during Period I when the birds were starting to come into production. The highest feed consumption (134.6 g) occurred during Period III. Although there was no significant difference between diets, it should be noted that the hens receiving Diet 232 consumed slightly more feed during each period than did the hens receiving Diet 231. The overall period averages were 116.2 and 121.2 g of feed consumed per hen per day for Diets 231 and 232, respectively, resulting in a savings of 5 g of feed per day with the 16% protein diet. A similar trend was present among the caged layers where the hens receiving Diet 231 consumed 4 g less feed per day than those receiving Diet 232. Highly significant ($P<.01$) interactions were noted for both strain x period and for diet x strain x period.

Comparison of the overall period averages of the two strains revealed that the Regional Control layers consumed 7.2 g of feed per day more than the DeKalb layers. This difference was not statistically significant.

Calculated Protein Consumption and Calculated Methionine Consumption

Grams of protein and milligrams of methionine consumed per hen per day are reported in tables 6 and 7, respectively. Protein consumption was calculated by multiplying the number of grams of feed consumed daily by the percent protein in the diet. Methionine consumption in milligrams was calculated by multiplying the grams of feed consumed daily by the percent methionine in the diet by 1000.

TABLE 6. CALCULATED GRAMS OF PROTEIN CONSUMED PER HEN-DAY DURING EXPERIMENT 1

	Period I	II	III	IV	Overall
	Environment House				
Period	15.2	17.1	20.2	17.8	17.8
Diet 231	16.0	18.2	20.8	18.4	18.5
Diet 232	14.1	16.1	18.4	16.8	16.5
DeKalb	15.4	17.0	19.4	16.9	17.4
Regional Control	14.2	17.2	21.2	19.3	18.4
	Cage Layers				
Diet 231	--	18.7	19.5	16.8	18.3
Diet 232	--	16.8	17.0	15.8	16.5

Analysis of Variance

Source	df	MS
P	3	37.37**
S	1	3.64
P X S	3	3.92**
D	1	32.00
P X D	3	0.25
S X D	1	0.04
P X S X D	3	7.75**
R	2	2.66
P X R	6	0.28
S X R	1	0.06
D X R	2	3.85
P X D X R	6	2.01
Error	7	0.05

TABLE 7. CALCULATED MILLIGRAMS OF METHIONINE CONSUMED PER HEN-DAY DURING EXPERIMENT 1

	Period I	II	III	IV	Overall
		Environment House			
Period	295	333	393	348	346
Diet 231	266	301	350	307	309
Diet 232	324	365	436	390	384
DeKalb	301	330	377	330	338
Regional Control	285	340	417	376	360
		Cage Layers			
Diet 231	--	312	324	279	304
Diet 232	--	381	384	357	374

Analysis of Variance

Source	df	MS
P	3	14351.45**
S	1	1326.12
P X S	3	1573.04**
D	1	35289.39*
P X D	3	465.00
S X D	1	4.50
P X S X D	3	3305.73**
R	2	1330.29
P X R	6	112.56
S X R	1	0.00
D X R	2	1825.23
P X D X R	6	998.54
Error	7	199.28

In calculating the percent methionine in Diet 232, MHA was calculated as having 80% methionine activity.

A highly significant difference ($P < .01$) was found among periods. Highly significant interactions ($P < .01$) occurred between strain x period and period x strain x diet for both protein and methionine consumption. The difference among periods was attributed to the smaller feed consumption during Period I. The interactions were undoubtedly due to the widely varying protein and methionine consumption of the Regional Control layers.

It should be noted that even though the layers receiving Diet 232 consumed more feed daily than those receiving Diet 231 they received less protein per day. The layers receiving Diet 232 consumed significantly more ($P < .05$) methionine daily.

Feed Efficiency

The data presented in table 8 show the feed efficiency in terms of kilograms of feed consumed per dozen eggs produced. Highly significant ($P < .01$) period differences were noted. Period differences were not only attributed to maturity differences but also were attributed to the increased feed consumption in Period III during which there was no corresponding increase in egg production. Although the difference between strains was not significant, it should be noted that the Regional Control layers consumed 4.35 kg of feed per dozen eggs produced compared to 3.14 kg for the DeKalb layers. The caged layers were more efficient than the environment house layers during all periods. This difference was attributed to

TABLE 8. FEED EFFICIENCY DURING EACH PERIOD OF EXPERIMENT 1 (KG FEED PER DOZEN EGGS)

	Period I	II	III	IV	Overall
		Environment House			
Period	3.80	3.30	4.05	3.39	3.62
Diet 231	3.48	3.07	3.89	3.22	3.41
Diet 232	4.13	3.53	4.21	3.57	3.83
DeKalb	2.98	2.82	3.53	3.17	3.14
Regional Control	5.05	4.02	4.82	3.73	4.35
		Cage Layers			
Diet 231	--	1.99	2.09	2.00	2.03
Diet 232	--	2.15	2.63	2.58	2.45

Analysis of Variance

Source	df	MS
P	3	1.14**
S	1	10.92
P X S	3	0.75
D	1	2.06
P X D	3	0.05
S X D	1	0.92
P X S X D	3	0.30
R	2	0.46
P X R	6	0.11
S X R	1	0.27
D X R	2	0.30
P X D X R	6	0.99
Error	7	0.08

the higher rate of production among caged layers rather than a decreased rate of feed consumption.

Egg Data

Average egg weight, average number of Haugh units per egg and average egg shell thickness for each period are reported in tables 9, 10 and 11, respectively.

The increase in egg size as the layers matured resulted in a highly significant difference ($P<.01$) between periods. Although the difference was not significant, the DeKalb layers produced an average egg size of 59.37 g which was 3.83 g heavier than the Regional Control layers (55.54 g). Egg sizes for the two different diets were slightly higher for caged layers when compared to slat floor layers. No significant difference was noted between Diets 231 and 232. A highly significant ($P<.01$) period x strain x diet interaction was also found.

Interior egg quality, as determined by Haugh units, showed a highly significant ($P<.01$) difference among periods. Very small, insignificant differences were noted between strains and diets.

No significant differences were noted among average egg shell thickness values.

Mortality

The average percent monthly mortality during each period is presented in table 12. Highly significant ($P<.01$) differences were found among periods and significant differences ($P<.05$) were found

TABLE 9. AVERAGE EGG WEIGHT (G), EXPERIMENT 1

	Period				
	I	II	III	IV	Overall
		Environment House			
Period	51.34	54.90	59.78	60.99	57.84
Diet 231	51.37	54.62	59.57	60.60	57.58
Diet 232	51.30	55.19	59.98	61.39	58.10
DeKalb	53.07	56.56	61.04	62.60	59.37
Regional Control	48.74	52.41	57.89	58.59	55.54
		Cage Layers			
Diet 231	--	59.76	62.16	63.42	62.01
Diet 232	--	60.32	63.34	64.45	63.00

Analysis of Variance

Source	df	MS
P	3	157.99**
S	1	118.00
P X S	3	0.45
D	1	0.67
P X D	3	0.33
S X D	1	0.09
P X S X D	3	42.17**
R	2	1.12
P X R	6	0.17
S X R	1	1.59
D X R	2	1.47
P X D X R	6	5.10
Error	7	0.03

TABLE 10. INTERIOR EGG QUALITY--HAUGH UNITS, EXPERIMENT 1

	Period II	Period III	Period IV	Overall
		Environment House		
Period	82.84	76.83	76.14	78.68
Diet 231	82.63	76.62	75.67	78.43
Diet 232	83.04	77.05	76.60	78.93
DeKalb	83.61	77.23	76.86	79.25
Regional Control	81.68	76.23	75.05	77.83
		Cage Layers		
Diet 231	82.91	74.64	71.20	75.41
Diet 232	83.85	74.48	72.14	75.94

Analysis of Variance

Source	df	MS
P	2	107.82**
S	1	11.64
P X S	2	0.18
D	1	1.52
P X D	2	0.34
S X D	1	4.65
P X S X D	2	3.98
R	2	1.48
P X R	4	2.07
S X R	1	1.15
D X R	2	2.20
P X D X R	4	1.60
Error	5	1.50

TABLE 11. EGG SHELL THICKNESS (MM), EXPERIMENT 1

	Period II	Period III	Period IV	Overall
		Environment House		
Period	0.3610	0.3652	0.3536	0.3595
Diet 231	0.3597	0.3632	0.3503	0.3573
Diet 232	0.3623	0.3672	0.3568	0.3617
DeKalb	0.3659	0.3702	0.3518	0.3617
Regional Control	0.3577	0.3618	0.3547	0.3581
		Cage Layers		
Diet 231	0.3646	0.3494	0.3469	0.3523
Diet 232	0.3683	0.3547	0.3541	0.3579

Analysis of Variance

Source	df	MS
P	2	0.00038
S	1	0.00012
P X S	2	0.00010
D	1	0.00015
P X D	2	0.00001
S X D	1	0.00001
P X S X D	2	0.00001
R	2	0.00004
P X R	4	0.00001
S X R	1	0.00008
D X R	2	0.00003
P X D X R	4	0.00003
Error	5	0.00003

TABLE 12. AVERAGE PERCENT MONTHLY MORTALITY, EXPERIMENT 1

	Period I	II	III	IV	Overall
	Environment House				
Period	2.16	5.51	0.70	0.42	2.20
Diet 231	2.46	4.13	0.84	0.36	1.90
Diet 232	1.86	6.90	0.57	0.47	2.50
DeKalb	2.90	2.12	0.48	0.44	1.36
Regional Control	1.06	10.61	1.03	0.38	3.47
	Cage Layers				
Diet 231	--	1.49	0.99	2.49	1.66
Diet 232	--	2.57	2.57	1.54	2.22

Analysis of Variance

Source	df	MS
P	3	3.3597**
S	1	0.7663*
P X S	3	1.8942
D	1	0.0131
P X D	3	0.1834
S X D	1	0.0644
P X S X D	3	0.1247
R	2	0.0679
P X R	6	0.2017
S X R	1	0.0021
D X R	2	0.0108
P X D X R	6	0.0437
Error	7	0.0464

between strains. Both of these differences were attributed to high mortality in the Regional Control birds during Period II. On several different occasions, smothering occurred in one or more pens of the Regional Control layers during the night. All 4 pens experienced smothering on one or more occasions during this period. As many as 20 birds died during one evening. It was theorized that a probable reason for the smothering occurring only among the Regional Control layers was the presence of roosters in these pens. The Regional Control layers were also slightly more crowded in the pens at the initiation of the experiment than were the DeKalb layers (160 birds vs. 140 birds). After smothering, there was a dramatic decrease in egg production for the pens affected. Many of the birds in these pens were severely injured from clawing and scratching.

Body Weight

Highly significant differences ($P<.01$) among periods and significant differences ($P<.05$) between strains were found for the bird weight data presented in table 13. The period differences were attributed to differences in sexual maturity. At the initiation of the experiment, the DeKalbs and the Regional Controls weighed essentially the same. At the termination of the trial, the DeKalb layers were 0.23 kg lighter than the Regional Controls. At all three weigh dates, there was essentially no difference between the weights of the birds within the same strain on the two different diets.

TABLE 13. AVERAGE BODY WEIGHT (KG) DURING THREE DIFFERENT PERIODS, EXPERIMENT 1

	Period II	Period III	Period IV
	Environment House		
Period	1.380	1.998	1.872
Diet 231	1.378	2.002	1.865
Diet 232	1.383	1.994	1.879
DeKalb	1.372	1.928	1.781
Regional Control	1.382	2.102	2.010
	Cage Layers		
Diet 231	--	--	1.910
Diet 232	--	--	2.000

Analysis of Variance

Source	df	MS
P	2	0.94516**
S	1	0.13741**
P X S	2	0.03655
D	1	0.00056
P X D	2	0.00014
S X D	1	0.00416
P X S X D	2	0.00011
R	2	0.00468
P X R	4	0.00302
S X R	1	0.00001
D X R	2	0.00367
P X D X R	4	0.00084
Error	5	0.00154

General Discussion

This experiment showed that the 14% protein corn-soy type diet supplemented with 0.1% methionine did not support as high a rate of egg production as the 16% protein corn-soy type diet. The results of this experiment are contradictory to the report of Carlson and Guenthner (1969). They showed that a 14% protein diet with supplemented methionine similar to the 14% protein diet tested in this experiment would support as good egg production as a 16% protein diet similar to the 16% protein diet tested in this experiment.

The experiments reported by Carlson and Guenthner were conducted in a cold wall house, whereas both the slat floor environment house layers and the caged layers in this experiment were in an insulated double wall house. It would seem logical to assume that the environmental conditions in this experiment should be much more conducive to a higher rate of egg production than those in the report of Carlson and Guenthner.

Carlson and Guenthner reported 60.9% hen-day egg production for all periods on a 16% protein diet and 64.4% production on a 14% protein diet supplemented with 0.1% methionine.

In this experiment, the caged layers receiving the 16% protein diet averaged 70.42% hen-day egg production during Periods II, III and IV, while the slat floor layers averaged 45.1%. The caged layers receiving the 14% protein methionine supplemented diet averaged 59.6% hen-day egg production while the slat floor layers averaged 42.1% during the same periods.

Relatively few problems were encountered in the cage layer house during the winter months, whereas many ventilation problems arose in the slat floor house. Among these were problems of both inadequate design and faulty operation. High ammonia concentrations and near freezing temperatures were encountered on several occasions.

It is possible that these reasons might explain the lower egg production of the environment house layers in relation to the caged layers. The DeKalb layers on slat floors averaged 49, 44 and 43% hen-day egg production during Periods II, III and IV, whereas the caged DeKalb layers averaged 72, 64 and 60%. From these data, it would appear to seem justified to assume that the egg production of the caged layers was a much more accurate index of the true value of the diets tested than the egg production of the slat floor layers. The level of production attained with the caged layers is similar to that shown by Carlson and Guenthner (1969), although the results showed different egg production values for the two diets.

Small differences were noted between the caged and slat floor DeKalb layers for feed consumption, protein consumption, methionine consumption and shell thickness. Egg weights were slightly higher for the caged layers and interior quality as measured by Haugh units was slightly lower. Less mortality occurred among the slat floor layers during Periods III and IV.

Experiment 2

The data from the layers in the environment house and the brooder house will be presented simultaneously. The data for individual pens in the environment house are presented in the appendix. Treatment means and analyses of variance will be presented in the text of this section.

Environment House and Brooder House

Egg Production. The treatment means for the monthly percent hen-day egg production for these two buildings are presented in table 14.

As mentioned previously in the Experimental Procedures, all 12 pens in the environment house were on slat floors until January when the slats were removed from 6 pens. The data presented as experiment 2A represent the months of November and December while the data from February and March are presented as experiment 2B. When discussing differences in the rate of egg production, the percentage increase or decrease between two treatments will refer to the actual difference between two treatments, not a percentage increase or decrease expressed relative to another production figure (e.g., Diet 1, 60%, vs. Diet 2, 50%; 10% difference = 10% increase for Diet 1).

In comparing the average production of the 6 pens on each of the two diets in the environment house with the production of one pen of each of the two diets in the brooder house during November, it was

TABLE 14. AVERAGE PERCENT HEN-DAY EGG PRODUCTION OF FLOOR LAYERS, EXPERIMENT 2[a]

	Experiment 2A		Experiment 2B	
	Nov.	Dec.	Feb.	March
		Environment House		
Month	45.12	56.95	58.18	55.94
Diet 231	46.73	58.19	58.25	55.42
Diet 232	43.50	55.71	58.10	56.46
Slat floor	--	--	51.36	48.44
Litter floor	--	--	65.00	63.45
North	46.76	59.81	59.75	57.86
Middle	43.94	53.67	53.53	51.92
South	44.66	57.38	61.27	58.05
		Brooder House		
Diet 231	63.19	79.45	80.07	76.64
Diet 232	57.87	71.97	76.44	72.07

Analyses of Variance[b]

Experiment 2A

Source	df	MS
M	1	839.81***
C	2	40.08
M X C	2	6.72
D	1	48.88
M X D	1	0.85
C X D	2	6.95
M X C X D	2	3.40
Error	12	21.83

Experiment 2B

Source	df	MS
M	1	29.97
C	2	114.46*
M X C	2	1.47
D	1	1.19
M X D	1	2.12
C X D	2	58.76
M X C X D	2	6.92
F	1	1230.66***
M X F	1	2.84
C X F	2	6.45
M X C X F	2	5.87
D X F	1	0.69
M X D X F	1	1.55
C X D X F	2	163.05*
Error	2	6.17

[a] The environment house means represent 12 pens. The data for each pen is given in the appendix. The brooder house data represent the performance of pens B1 and B2 in the brooder house.

[b] Abbreviations in analyses of variance tables for the floor layers in experiment 2 are: M = Month, C = Chamber, D = Diet and F = Floor.

noted that the percent hen-day egg production in the brooder house was 16.46% higher for Diet 231 and 14.37% higher for Diet 232. When this gap widened to 21.26% and 16.26% for each respective diet during December, the decision was made to remove the slats from 6 of the 12 pens in the environment house in an effort to duplicate conditions existing in the brooder house. A very highly significant difference ($P<.005$) was found to exist during experiment 2A between the two months. This was a reflection of sexual maturity.

As noted in table 14, the egg production of the layers on slat floors during February was 51.36% which was 14.64% lower than the layers on litter floor (65.00%). The production of the layers on litter floor in the environment house was 13.25% lower than the average production (78.25%) of the two pens in the brooder house.

In March, the gap between the production of layers on litter floor (63.45%) and slat floor layers (48.44%) widened to 15.01%. The egg production of the floor layers in the environment house was 10.90% lower than the average production of the two pens in the brooder house (74.35%).

The difference between the slat floor layers and the litter floor layers in the environment house during experiment 2B was found to be very highly significant ($P<.005$). The differences between the chambers of the environment house were found to be significant ($P<.05$) as was a chamber x diet x floor interaction. The Middle chamber, which was the coldest chamber (45° F.) had the lowest egg production.

No significant differences were noted between hens on Diets 231 and 232 in the environment house for either experiments 2A or 2B. During all months in the two pens in the brooder house, the hens on Diet 231 performed at a higher rate than those on Diet 232.

Feed Consumption. Feed consumption data expressed as grams of feed consumed daily are given in table 15. For experiment 2A, significant differences ($P<.05$) were noted between the chambers, between the diets and for a chamber x month interaction with the layers in the environment house. The very highly significant difference ($P<.005$) which occurred between months was attributed to sexual maturity. As found in experiment 1, the feed consumption of the layers receiving Diet 232 was higher than that of the layers receiving Diet 231. This is of added importance in this trial because the diets were formulated to be isocaloric. The feed consumption of the layers in the North chamber was considerably less than that of the layers in the other two chambers during the month of December. The temperature in this chamber was maintained at 60° F. with supplemental heat. At this temperature, which should not have fluctuated much, it would be anticipated that feed consumption would be considerably less than if the birds were in an environment such as the Middle or South chambers where the room temperature was cooler due to the air movement maintained and the lack of supplemental heat. The layers in the Middle chamber, which was the coolest chamber, consumed the largest amount of feed per hen day. In experiment 2B, no significant differences between chambers were found.

TABLE 15. GRAMS OF FEED CONSUMED PER HEN-DAY, EXPERIMENT 2

	Experiment 2A		Experiment 2B	
	Nov.	Dec.	Feb.	March
Environment House				
Month	94.1	102.0	105.9	102.1
Diet 231	92.9	99.9	105.5	102.1
Diet 232	95.3	104.1	106.3	102.1
Slat floor	--	--	106.4	102.7
Litter floor	--	--	105.4	101.5
North	94.4	96.2	106.3	102.0
Middle	94.8	106.4	104.8	101.9
South	93.1	103.4	106.6	102.4
Brooder House				
Diet 231	82.6	98.1	93.5	101.2
Diet 232	83.5	98.1	91.6	100.8

Analysis of Variance

Experiment 2A			Experiment 2B		
Source	df	MS	Source	df	MS
M	1	373.67***	M	1	86.64**
C	2	54.82*	C	2	2.59
M X C	2	56.05*	M X C	2	1.09
D	1	67.00*	D	1	1.04
M X D	1	4.59	M X D	1	0.67
C X D	2	26.50	C X D	2	0.57
M X C X D	2	9.49	M X C X D	2	4.00
Error	12	12.40	F	1	6.83
			M X F	1	0.04
			C X F	2	0.69
			M X C X F	2	7.48
			D X F	1	22.43*
			M X D X F	1	0.08
			C X D X F	2	25.75*
			Error	2	0.45

In experiment 2B, significant differences ($P < .05$) were found for the diet x floor interaction and a chamber x diet x floor interaction. A highly significant difference ($P < .01$) was found between months.

In comparing the environment house layers with pens B1 and B2 in the brooder house during experiment 2A, it is noted that the feed consumption of the environment house birds was approximately 10 g more in November and 4 g more in December. In experiment 2B, the environment house layers consumed approximately 13 more g of feed per day during February. There was little difference between the two houses in March.

No significant differences were found between the daily feed consumption of the slat floor layers and the litter floor layers in experiment 2B.

Within the brooder house, there was little difference between the daily consumption of the two diets.

Protein and Methionine Consumption. Grams of protein (calculated) and milligrams of methionine (calculated) consumed per hen-day are reported in tables 16 and 17. Differences in feed consumption accounted for most of the differences between protein and methionine consumption. In experiments 2A and 2B, protein and methionine consumption were very highly significantly different ($P < .005$) between the two diets. In all months reported, the layers receiving Diet 232 consumed more feed than the layers receiving Diet 231, but the daily protein intake was always less. The layers

TABLE 16. CALCULATED GRAMS OF PROTEIN CONSUMED PER HEN-DAY, EXPERIMENT 2

	Experiment 2A		Experiment 2B	
	Nov.	Dec.	Feb.	March
	Environment House			
Month	14.1	15.2	15.8	15.3
Diet 231	14.8	15.9	16.8	16.3
Diet 232	13.3	14.5	14.8	14.3
Slat floor	--	--	15.9	15.4
Litter floor	--	--	15.8	15.2
North	14.1	14.4	15.9	15.3
Middle	14.2	15.9	15.7	15.3
South	13.9	15.4	15.9	15.4
	Brooder House			
Diet 231	13.2	15.6	14.9	16.2
Diet 232	11.6	13.7	12.8	14.1

Analyses of Variance

Experiment 2A			Experiment 2B		
Source	df	MS	Source	df	MS
M	1	8.17***	M	1	1.65*
C	2	1.33*	C	2	0.04
M X C	2	1.21*	M X C	2	0.02
D	1	12.61***	D	1	24.20***
M X D	1	0.01	M X D	1	0.00
C X D	2	0.69	C X D	2	0.02
M X C X D	2	0.14	M X C X D	2	0.09
Error	12	0.26	F	1	0.18
			M X F	1	0.00
			C X F	2	0.03
			M X C X F	2	0.20
			D X F	1	0.51*
			M X D X F	1	0.00
			C X D X F	2	0.68*
			Error	2	0.02

TABLE 17. CALCULATED MILLIGRAMS OF METHIONINE CONSUMED PER HEN-DAY, EXPERIMENT 2

	Experiment 2A		Experiment 2B	
	Nov.	Dec.	Feb.	March
		Environment House		
Month	274	297	308	298
Diet 231	247	265	280	272
Diet 232	302	330	337	324
Slat floor	--	--	310	299
Litter floor	--	--	307	296
North	276	281	310	297
Middle	275	310	306	297
South	271	302	310	299
		Brooder House		
Diet 231	220	261	249	269
Diet 232	265	279	290	320

Analyses of Variance

Experiment 2A			Experiment 2B		
Source	df	MS	Source	df	MS
M	1	3243.37***	M	1	725.99***
C	2	408.79	C	2	17.37
M X C	2	508.62*	M X C	2	8.37
D	1	21420.37***	D	1	17821.50***
M X D	1	126.04	M X D	1	24.00
C X D	2	165.37	C X D	2	2.62
M X C X D	2	114.54	M X C X D	2	39.12
Error	12	108.69	F	1	48.17*
			M X F	1	0.67
			C X F	2	1.54
			M X C X F	2	58.04*
			D X F	1	181.50*
			M X D X F	1	0.67
			C X D X F	2	217.12
			Error	2	2.20

receiving Diet 232 consumed more methionine than the layers receiving Diet 231. Numerous interactions of various degrees of significance are given in tables 16 and 17.

Feed Efficiency. Very highly significant differences ($P<.005$) occurred between months in experiment 2A for the feed efficiency data shown in table 18. Significant differences ($P<.05$) occurred among chambers and between diets. Feed conversion was poorest in the Middle chamber in light of the high feed consumption in this chamber, particularly during December. The most efficient production occurred in the North chamber where feed consumption was lowest during December. In each month of experiment 2A, Diet 231 was more efficient ($P<.05$) than Diet 232 for the environment house layers. Diet 231 was more efficient during all four months of experiments 2A and 2B in the brooder house.

A highly significant difference ($P<.01$) was found between the slat and litter floors in experiment 2B. This was due to the increased egg production from the layers on the litter floor.

Egg Data. Average egg weight, Haugh units, and average egg shell thickness are reported in tables 19, 20 and 21.

Aside from differences between months, no significant differences were noted in experiments 2A and 2B for average egg weight.

In experiment 2A, very highly significant differences ($P<.005$) occurred between months and between chambers for Haugh units. Increases in egg weight resulted in lower Haugh units with

TABLE 18. FEED EFFICIENCY DURING EACH MONTH OF EXPERIMENT 2 (KG FEED PER DOZEN EGGS)

	Experiment 2A		Experiment 2B	
	Nov.	Dec.	Feb.	March
	Environment House			
Month	2.51	2.17	2.24	2.25
Diet 231	2.38	2.08	2.22	2.28
Diet 232	2.63	2.25	2.25	2.22
Slat floor	--	--	2.52	2.58
Litter floor	--	--	1.95	1.92
North	2.43	1.95	2.16	2.14
Middle	2.59	2.38	2.41	2.42
South	2.51	2.18	2.15	2.20
	Brooder House			
Diet 231	1.57	1.48	1.40	1.58
Diet 232	1.73	1.63	1.44	1.67

Analyses of Variance

Experiment 2A

Source	df	MS
M	1	0.69***
C	2	0.17*
M X C	2	0.04
D	1	0.26*
M X D	1	0.01
C X D	2	0.04
M X C X D	2	0.02
Error	12	0.04

Experiment 2B

Source	df	MS
M	1	0.000
C	2	0.166
M X C	2	0.002
D	1	0.002
M X D	1	0.015
C X D	2	0.154
M X C X D	2	0.016
F	1	2.245**
M X F	1	0.010
C X F	2	0.027
M X C X F	2	0.022
D X F	1	0.016
M X D X F	1	0.012
C X D X F	2	0.215
Error	2	0.013

TABLE 19. AVERAGE EGG WEIGHT (G), EXPERIMENT 2

	Experiment 2A		Experiment 2B	
	Nov.	Dec.	Feb.	March
		Environment House		
Month	47.92	51.53	55.96	56.93
Diet 231	47.98	51.32	55.62	56.70
Diet 232	47.86	51.75	56.30	57.17
Slat floor	--	--	56.16	57.08
Litter floor	--	--	55.76	56.79
North	48.22	51.66	56.05	56.92
Middle	48.06	51.87	56.13	57.43
South	47.47	51.08	55.71	56.45
		Brooder House		
Diet 231	46.72	50.97	55.90	57.35
Diet 232	47.40	51.86	56.95	57.45

Analyses of Variance

Experiment 2A			Experiment 2B		
Source	df	MS	Source	df	MS
M	1	78.44***	M	1	5.66*
C	2	1.23	C	2	1.01
M X C	2	0.07	M X C	2	0.17
D	1	0.15	D	1	2.01
M X D	1	0.46	M X D	1	0.07
C X D	2	0.76	C X D	2	0.16
M X C X D	2	0.14	M X C X D	2	0.00
Error	12	0.35	F	1	0.72
			M X F	1	0.02
			C X F	2	0.08
			M X C X F	2	0.08
			D X F	1	1.90
			M X D X F	1	0.01
			C X D X F	2	0.59
			Error	2	0.21

TABLE 20. INTERIOR EGG QUALITY--HAUGH UNITS, EXPERIMENT 2

	Experiment 2A Nov.	Experiment 2A Dec.	Experiment 2B Feb.	Experiment 2B March
	Environment House			
Month	86.18	77.87	68.67	71.74
Diet 231	85.62	78.61	67.87	71.86
Diet 232	86.74	77.13	69.46	71.62
Slat floor	--	--	68.27	72.20
Litter floor	--	--	69.07	71.29
North	86.72	81.48	69.64	72.86
Middle	86.14	76.74	67.91	71.17
South	85.67	75.39	68.46	71.20
	Brooder House			
Diet 231	87.79	80.60	70.31	71.61
Diet 232	86.75	79.76	74.18	73.36

Analyses of Variance

Experiment 2A Source	df	MS	Experiment 2B Source	df	MS
M	1	414.59***	M	1	56.76
C	2	27.42***	C	2	6.74
M X C	2	14.60**	M X C	2	0.17
D	1	0.18	D	1	2.74
M X D	1	10.26*	M X D	1	5.01
C X D	2	2.78	C X D	2	0.15
M X C X D	2	2.57	M X C X D	2	0.99
Error	12	1.96	F	1	0.02
			M X F	1	4.39
			C X F	2	13.07
			M X C X F	2	1.92
			D X F	1	15.70
			M X D X F	1	1.42
			C X D X F	2	16.13
			Error	2	9.32

TABLE 21. EGG SHELL THICKNESS (MM), EXPERIMENT 2[a]

	Experiment 2A Nov.	Experiment 2B Feb.	March
	Environment House		
Month	0.3332	0.3545	0.3380
Diet 231	0.3336	0.3568	0.3371
Diet 232	0.3329	0.3522	0.3389
Slat floor	--	0.3467	0.3353
Litter floor	--	0.3623	0.3408
North	0.3273	0.3565	0.3415
Middle	0.3368	0.3558	0.3391
South	0.3356	0.3513	0.3335
	Brooder House		
Diet 231	0.3276	0.3580	0.3660
Diet 232	0.3324	0.3648	0.3260

Analyses of Variance

Experiment 2A Source	df	MS	Experiment 2B Source	df	MS
C	2	0.00010	M	1	0.001633*
D	1	0.00000	C	2	0.000095
C X D	2	0.00005	M X C	2	0.000004
Error	5	0.00004	D	1	0.000012
			M X D	1	0.000062
			C X D	2	0.000060
			M X C X D	2	0.000008
			F	1	0.000670*
			M X F	1	0.000152
			C X F	2	0.000086
			M X C X F	2	0.000021
			D X F	1	0.000286
			M X D X F	1	0.000085
			C X D X F	2	0.000044
			Error	2	0.000020

[a] Data for December accidentally destroyed.

increasing maturity. No logical reason seems apparent for the differences among chambers. A highly significant difference ($P<.01$) existed for the month x chamber interaction and a significant difference ($P<.05$) existed for the month x diet interaction. No significant differences among Haugh units were found for experiment 2B.

No significant differences were found for the egg shell data in experiment 2A. In experiment 2B, significant differences ($P<.05$) were found between months and between slat and litter floors. The decrease in shell thickness between February and March was undoubtedly due to the advancing age of the layers. The greater shell thickness of the layers on litter floor when compared to the slat floors, even though significant, was considered by the author to be of little importance because it was only approximately 0.005 mm.

Mortality. Mortality data presented in table 22 revealed no significant differences in either experiment 2A or 2B. The average percent monthly mortality for each month was always less than 1%.

Body Weight. Very highly significant differences ($P<.005$) existed between months in experiment 2A for the body weight data presented in table 23. A significant ($P<.05$) chamber x diet interaction was also found. No significant differences were found in experiment 2B.

TABLE 22. AVERAGE PERCENT MONTHLY MORTALITY, EXPERIMENT 2

	Experiment 2A		Experiment 2B	
	Nov.	Dec.	Feb.	March
		Environment House		
Month	0.95	0.89	0.77	0.89
Diet 231	0.83	0.83	1.18	0.83
Diet 232	1.07	0.95	0.35	0.95
Slat floor	--	--	0.59	1.19
Litter floor	--	--	0.95	0.59
North	0.53	1.25	0.71	0.18
Middle	0.35	0.89	1.07	1.43
South	1.96	0.53	0.53	1.07
		Brooder House		
Diet 231	0.71	0.00	0.71	0.00
Diet 232	0.00	0.71	0.71	0.71

Analyses of Variance

Experiment 2A			Experiment 2B		
Source	df	MS	Source	df	MS
M	1	29.04	M	1	57.04
C	2	1026.91	C	2	1879.03
M X C	2	4380.64	M X C	2	1423.44
D	1	369.73	D	1	1926.04
M X D	1	10.14	M X D	1	2109.37
C X D	2	1944.79	C X D	2	173.52
M X C X D	2	372.94	M X C X D	2	844.97
Error	12	1330.51	F	1	139.20
			M X F	1	2109.37
			C X F	2	755.96
			M X C X F	2	1972.37
			D X F	1	1737.40
			M X D X F	1	1571.40
			C X D X F	2	1729.61
			Error	2	355.32

TABLE 23. AVERAGE BODY WEIGHT (KG) ON THREE WEIGH DATES DURING EXPERIMENT 2

	Experiment 2A		Experiment 2B
	Nov.	Dec.	March
	Environment House		
Month	1.278	1.644	1.712
Diet 231	1.278	1.647	1.711
Diet 232	1.278	1.640	1.714
Slat floor	--	--	1.725
Litter floor	--	--	1.700
North	1.283	1.654	1.711
Middle	1.278	1.640	1.719
South	1.273	1.637	1.707
	Brooder House		
Diet 231	1.358	1.620	1.686
Diet 232	1.374	1.637	1.694

Analyses of Variance

Experiment 2A			Experiment 2B		
Source	df	MS	Source	df	MS
M	1	0.80263***	C	2	0.000150
C	2	0.00040	D	1	0.000030
M X C	2	0.00004	C X D	2	0.000230
D	1	0.00007	F	1	0.001704
M X D	1	0.00007	C X F	2	0.000582
C X D	2	0.00122*	D X F	1	0.001665
M X C X D	2	0.00025	Error	2	0.000740
Error	12	0.00028			

Caged Layers

The performance of the caged layers during experiments 2A and 2B is reported in table 24. The analyses of variance are presented in table 25.

During experiment 2A, a very highly significant difference ($P < .005$) was noted between the two months for egg production. No significant differences were found for daily feed consumption or daily protein consumption. There was a highly significant difference ($P < .01$) between months for feed efficiency. The layers receiving Diet 232 consumed significantly more ($P < .05$) methionine. The layers receiving Diet 231 consumed significantly more protein ($P < .05$). In this trial, hens on the two diets showed about equal performances and Diet 232 would be the diet of choice if economic conditions warranted. Highly significant differences ($P < .01$) existed between months for average egg weight and very highly significant differences ($P < .005$) were noted between months for Haugh unit values. No other significant differences were noted for egg weight and Haugh unit values or between treatments for egg shell thickness values.

Aside from a significant ($P < .05$) diet x cage/rep interaction, no significant differences were noted for egg production in experiment 2B. A very highly significant difference ($P < .005$) was noted between the feed efficiency of the two diets. This was attributed to the smaller feed consumption of Diet 231 during both months. The layers receiving Diet 232 received very highly significantly more

TABLE 24. PERFORMANCE OF CAGE LAYERS, EXPERIMENT 2[a]

	Diet	November	December	February	March
Percent hen-day egg production	231	47.88	72.12	69.47	72.27
	232	47.78	74.73	70.40	71.24
Grams feed consumed per hen-day	231	79.1	101.0	117.7	118.8
	232	88.58	94.82	118.3	121.3
Grams protein consumed per hen-day	231	12.65	16.20	18.82	19.00
	232	12.38	13.28	16.55	16.98
Milligrams of methionine consumed per hen-day	231	210.4	268.9	313.2	316.9
	232	298.4	319.2	398.7	408.7
Feed efficiency (kg feed per dozen eggs)	231	1.98	1.69	2.04	1.98
	232	2.26	1.52	2.02	2.05
Egg weight (g)	231	44.89	51.25	57.00	58.85
	232	46.38	51.90	57.75	59.34
Shell thickness (mm)	231	0.3578	0.3432	0.3585	0.3475
	232	0.3437	0.3472	0.3618	0.3528
Average Haugh units	231	85.84	79.46	76.60	70.14
	232	86.79	78.52	74.16	72.19
Percent mortality	231	0.00	2.08	1.04	0.00
	232	0.00	0.00	2.08	2.08
Bird weight (kg)[b]	231	1.359	1.692	--	1.897
	232	1.336	1.671	--	1.857

[a] The data reported are the average of four replicates.
[b] No statistical analysis performed for weight data in experiment 2B.

TABLE 25. ANALYSES OF VARIANCE, CAGED LAYERS, EXPERIMENT 2

Source	df	Percent hen-day egg production		Body weight
		Experiment 2A MS	Experiment 2B MS	Experiment 2A MS
Rep	3	40.04	81.65	0.02060
Month	1	10498.05***	61.07	1.78891***
Rep x Month	3	102.05	11.00	0.00769
Diet	1	24.33	0.01	0.00765
Rep x Diet	3	183.65	65.82	0.00107
Month x Diet	1	28.65	10.76	0.00003
Rep x Month x Diet	3	31.42	34.23	0.00412
Cage/Rep	12	73.88	92.44	0.00666
Month x Cage/Rep	12	41.77	9.94	0.00226
Diet x Cage/Rep	12	81.54	108.06*	0.09782***
Error	12	77.42	38.48	0.00286

TABLE 25 CONTINUED

Source	df	Egg weight 2A MS	Egg weight 2B MS	Haugh units 2A MS	Haugh units 2B MS	Shell thickness 2A MS	Shell thickness 2B MS	Grams feed 2A MS	Grams feed 2B MS
Rep	3	1.39	0.51	7.79	4.96	0.00005	0.00018	25.42	46.19
Month	1	141.19**	12.11*	214.55***	71.06*	0.00012	0.00036	796.65	16.00
Rep x Month	3	1.47	0.08	0.24	3.60	0.00006	0.00017	128.20	2.05
Diet	1	4.57	1.48	0.00	0.15	0.00010	0.00009	10.08	9.61
Rep x Diet	3	1.88	0.96	7.20	4.76	0.00019	0.00011	58.60	53.36*
Month x Diet	1	0.70	0.05	3.56	20.11	0.00033	0.00000	247.28	3.80
Error	3	3.55	1.02	2.60	2.09	0.00022	0.00016	105.82	2.43

TABLE 25 CONTINUED

Source	df	Grams protein 2A MS	Grams protein 2B MS	Milligrams methionine 2A MS	Milligrams methionine 2B MS	Feed efficiency 2A MS	Feed efficiency 2B MS
Rep	3	0.51	1.12*	287.09	371.95*	1.39	1.12*
Month	1	19.80	0.36	6328.20	161.92	141.19**	0.36
Rep x Month	3	2.55	0.05	1419.64	19.00	1.47	0.05
Diet	1	10.24	18.49***	19251.56*	31781.98***	4.57	18.49***
Rep x Diet	3	1.27	1.36*	578.33	432.55*	1.88	1.36*
Month x Diet	1	7.02	0.06	1398.76	52.92	0.70	0.06
Error	3	2.02	0.06	1216.83	23.13	3.55	0.06

($P < .005$) methionine daily and those receiving Diet 231 received very highly significantly more ($P < .005$) protein daily. Significant differences ($P < .05$) in feed efficiency, grams of protein consumed daily and milligrams of methionine consumed daily were noted among replicates and for the replicate x diet interaction. Significant differences ($P < .05$) occurred between months for both average egg weight and Haugh unit values.

General Discussion

Numerous significant differences between months in experiments 2A and 2B can be attributed to the sexual maturity of the layers.

Experiment 2B revealed a dramatic difference in egg production between slat floor and litter floors within the environment house. When the slats were removed from 6 of the 12 pens and the layers placed on floor litter, the layers on the floor litter laid eggs at a rate (approximately 65%) which was almost 15% greater than those on slat floors (approximately 50%). The production of the layers on litter floor was about 10% lower than the two pens maintained in the brooder house throughout experiment 2B. The caged layers averaged approximately 70% hen-day egg production for the months of December, February and March. The two pens in the brooder house averaged approximately 75%.

Many theories have been put forth to explain the lower egg production in the environment house. Among the theories and conclusions put forth are:

1. The two diets (Diet 231 and Diet 232) gave adequate egg production in both the cage layer house and the brooder house. Thus, the fact that the environment house layers on slat floors did not have access to their feces should contribute little significance to the difference between the two systems of floor management.

2. Even with the variations introduced in environment during experiment 2, few differences in egg production were noted between chambers of the environment house. The only significant difference occurred during experiment 2B when hens in the Middle chamber were significantly lower ($P<.05$) in rate of egg production. Thus, ventilation problems and temperature fluctuations proved to be of little importance in comparing the three buildings. This is also verified by the differences obtained between slat floor and litter floors within the same chamber during experiment 2B.

3. The layers on slat floors may have laid just as many eggs as the layers on litter floors. However, it is possible that many of the so-called "floor eggs" laid on the slat floor instead of the nests may have been eaten by the chickens and thus were never counted. However, examination of the feces under the slats revealed relatively few pieces of broken shells. The layers on litter floor may not have had the desire or intuition to eat nearly as many floor eggs due to the fact that they had access to the litter.

4. Stress may have been placed upon the layers on the slat floors by factors such as crowding. Typical density levels were maintained but perhaps the small pen size was a factor.

Experiment 2 was not originally intended to study the differences between slat and litter floors and thus it is impossible to form any definite conclusions as to the cause of reduced egg production on the slat floors.

There were no significant differences between Diets 231 and 232 for the environment house layers and for the caged layers. However, hens in the one pen on Diet 231 performed considerably better than those on Diet 232 in the brooder house.

In three out of the four months, the layers in the environment house receiving Diet 232 consumed more feed than those receiving Diet 231. The difference was significant ($P<.05$) in experiment 2A.

In all cases, the layers receiving Diet 231 consumed more protein daily than the layers receiving Diet 232. The feed intake data showed that the hens receiving Diet 232 were eating more feed than required to meet their calorie needs in order to fulfill the need for protein.

All layers receiving Diet 232 consumed significantly more methionine than those receiving Diet 231. This is explained by the increased level of methionine in Diet 232 which was attained by supplementation with MHA.

Feed efficiency data showed more efficient production for the birds receiving Diet 231 in the brooder house during all four months. Similarly, Diet 231 was superior for three out of the four months in the environment house and two out of four months in the cage house.

Aside from maturity differences, there were no major differences as influenced by diet which were considered to be of practical significance for egg weight, Haugh units, egg shell thickness, mortality and body weight.

SUMMARY

A 14% protein corn-soy type diet supplemented with 0.1% methionine hydroxy analogue (MHA) was compared to a 16% protein corn-soy type diet in two separate studies over a two year period.

The first study, which was 11 months in duration, involved 829 DeKalb 131 chickens and 616 Cornell Regional Control Single Comb White Leghorns housed in 12 slat floor pens within three environmental chambers in a building referred to as the environment house and 132 DeKalb 131 layers housed in cages. Environmental conditions were maintained essentially the same by means of the design for the two buildings. The environment house layers were fed the experimental diets at 20 weeks of age, while the caged layers were fed a 16% protein diet until 28 weeks of age and were then placed on the experimental diets. The monthly data were summarized on the basis of similar environmental temperatures into four periods: Period I, October through November; Period II, December through February; Period III, March through May and Period IV, June through August.

Egg production of the cage layers was within a range of what would be considered normal for the diets tested. While egg production of the slat floor layers was somewhat below what might be expected, the following conclusions were drawn:

1. Hens in cages receiving the 16% protein diet produced significantly more ($P < .01$) eggs than those on the 14% protein methionine supplemented diet. The layers receiving the 16% protein diet had an average hen-day egg production for all periods of 70.42%

compared to 59.59% for those on the 14% protein diet. The 16% protein diet was thus the diet of choice in this experiment.

2. Although the difference was not statistically significant, the environment house layers receiving the 16% protein diet had a hen-day egg production record which was 2.67% higher than the layers receiving the 14% protein diet.

3. The difference in egg production between the DeKalb layers (45.43%) and the Cornell Regional Control layers (38.31%) was non-significant.

4. High mortality during Period II of the Cornell Regional Control layers and improperly adjusted ventilation are partially attributed to causing poor performance of the layers in the environment house. The difference in mortality between the two strains was significant ($P<.05$).

5. Aside from period differences, no statistically significant differences were noted for feed efficiency, feed consumption, average egg weight, Haugh units and egg shell thickness.

6. The Cornell Regional Control layers weighed significantly more ($P<.01$) than the DeKalb layers at the three weigh dates during the trial.

In experiment 2, DeKalb 151 layers were used exclusively for all studies. One hundred forty pullets were placed in each of the 12 pens in the slat floor environment house and 2 pens on litter floor in a building referred to as the brooder house. One hundred ninety-two caged layers were also included in this study. The data were recorded on a monthly basis and statistically analyzed as two separate groups. Experiment 2A covered the months of November and December while experiment 2B covered the months of February and March. Unlike experiment 1, the temperatures in the three chambers in the environment house were not identical. The temperatures used were North, 60° F. (with supplemental heat); South, 50° F. and Middle, 45° F. Thus, the layers were tested in five different environments during this trial. Between experiments 2A and 2B, the slat floors were removed from 6 of the 12 pens in the environment house. The hens in these pens were then placed on crushed corn cob litter.

The following conclusions were drawn from the studies conducted within experiment 2:

1. The use of slat floors in the environment house reduced egg production drastically. For the month of December in experiment 2A, during which all of the hens in the environment house were on slat floors, the average percent hen-day egg production of all 12 pens was approximately 20% lower than that of the 2 pens in the brooder house on litter floor.

In February of experiment 2B, the 6 pens in the environment house which remained on slat floors showed an average hen-day egg production rate of approximately 50%. The layers which were moved to floor litter showed production of approximately 65%. Corresponding figures for the brooder house and the cage house were 75% and 70%, respectively. A similar trend was noted for the month of March.

The differences between the egg production of the slat floor and litter floor layers for experiment 2B were very highly significant ($P < .005$).

The experiment was not designed to establish the reasons for the difference between the production of the slat floor and the litter floor layers.

2. Although there was no significant difference in performance between the two diets tested in the environment house during either experiments 1, 2A or 2B, it was felt that the data obtained in this building were not a true representation of the potential of either diet and no conclusions should be drawn on their usage from this facet of experiments 1, 2A and 2B.

3. Within the brooder house, hens in the one pen on the 16% protein diet outperformed those on the 14% protein methionine supplemented diet for egg production during all four months. These data could not be analyzed statistically. No significant differences in performance were noted between the two diets for the caged layers. However, feed consumption was significantly greater ($P < .05$) for the 14% protein methionine supplemented diet during experiment 2A.

4. During all months, the hens receiving the 16% protein diet consumed more daily protein than did the birds receiving the 14% protein methionine supplemented diet. The hens receiving the latter diet consumed more methionine.

5. Aside from maturity differences, there were few significant differences of practical importance for the treatments used on the

average egg weight, Haugh units, egg shell thickness, body weight or mortality.

From the results of experiments 1 and 2, there does not appear to be sufficient justification to recommend that the 16% protein corn-soy type diet be replaced with the 14% protein corn-soy type diet supplemented with 0.1% methionine. During certain periods within the lives of certain strains of hens, satisfactory performance might be attained with the latter diet.

In experiment 1, the caged hens on the 16% protein diet outperformed those on the 14% protein diet. In experiment 2, there was no significant difference between the diets for caged layers. However, the 16% protein diet outperformed the 14% protein methionine supplemented diet in 2 pens of layers maintained on litter floors throughout the duration of the experiment. A trend for the birds receiving the 14% protein methionine supplemented diet to consume more feed was noted throughout both experiments 1 and 2. Thus, it appears from these studies that it is extremely unlikely that any economic advantage would be gained by lowering the protein level of laying hen diets from 16% to 14% protein supplemented with methionine.

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APPENDIX

TABLE 1. AVERAGE COMPOSITION OF THE DIETS FED, EXPERIMENTS 1 AND 2[a,b]

Ingredient	Experiment 1 Diet 231	Experiment 1 Diet 232	Experiment 2 Diet 231	Experiment 2 Diet 232
	lb	lb	lb	lb
Ground yellow corn	662	714	660	730
Soybean meal (solvent extracted)	208	155	200	144
Alfalfa meal (17%)	20	20	20	20
Yellow grease	30	30	40	25
Ground limestone[c]	50	50	50	50
Dicalcium phosphate[d]	20	20	20	20
Trace mineral salt[e]	5	5	5	5
Poultry vitamin premix[f]	5	5	5	5
MHA[g]	0	1	0	1
Total	1000	1000	1000	1000

[a] Pounds per 1000 pounds.

[b] Corn to soybean meal ratios were altered whenever new sources of these ingredients were purchased to maintain Diet 231 at 16% protein and Diet 232 at 14% protein. Corn to soybean meal ratios used and the period of time during which they were used are given in table 25. The average composition represents a mean of all the different corn to soybean meal ratios based on the length of time they were fed.

[c] 37% calcium.

[d] Feed grade dicalcium phosphate, minimum of 18 1/2% phosphorus, minimum of 24.5% calcium.

[e] Trace mineral salt contained 93.5 to 96.5% sodium chloride, 0.5 to 1.0% calcium, 0.25% phosphorus, 0.25% manganese, 0.01% cobalt, 0.133% copper, 0.3% zinc, 0.007% iodine, 0.130% iron (II), 0.120% iron (III) and 0.250% sulfur.

[f] Poultry vitamin premix, Chas. Pfizer and Co., Inc., New York, New York. Each pound contained: 500,000 U.S.P. units vitamin A, 200,000 I.C. units vitamin D_3, 2,000 units vitamin E, 400 milligrams riboflavin, 800 milligrams d-pantothenic acid, 4,000 milligrams niacin, 46,088 milligrams choline chloride, 0.8 milligrams vitamin B_{12} activity, 32.8 milligrams menadione, 100 milligrams folic acid, 10 milligrams biotin and 10 grams of ethoxyquin as a preservative.

[g] Methionine hydroxy analogue calcium, Monsanto Co., St. Louis, Missouri.

TABLE 2. CORN AND SOYBEAN RATIOS DURING EXPERIMENT 1 AND CORN, SOYBEAN AND YELLOW GREASE RATIOS DURING EXPERIMENT 2

Dates ratios used	Diet 231 (16% protein) % corn	Diet 231 (16% protein) % soy	Diet 232 (14% protein) % corn	Diet 232 (14% protein) % soy
	Experiment 1			
Oct. 1-Dec. 1	76.57	23.43	82.63	17.37
Dec. 1-Dec. 10	78.28	21.72	83.77	16.23
Dec. 10-Dec. 12	76.90	23.10	82.85	17.15
Dec. 12-Jan. 8	75.52	24.48	81.70	18.30
Jan. 8-Jan. 29	78.97	21.03	85.27	14.73
Jan. 29-March 12	74.60	25.40	80.44	19.56
March 12-July 11	75.63	24.37	81.59	18.24
July 11-July 29	77.01	22.99	82.97	17.03
July 29-Aug. 24	76.55	23.45	82.74	17.26
Avg composition[a]	76.09	23.91	82.16	17.84

Experiment 2

	Diet 231 (16% protein) % corn	Diet 231 (16% protein) % soy	Diet 231 (16% protein) % yellow grease	Diet 232 (14% protein) % corn	Diet 232 (14% protein) % soy	Diet 232 (14% protein) % yellow grease
Nov. 1-Feb. 2	73.56	22.00	4.44	81.54	15.68	2.78
Feb. 3-March 31	72.78	22.67	4.55	80.53	16.47	3.00
Avg composition	73.27	22.25	4.48	81.16	15.98	2.86

[a] Average composition was calculated by finding the sum of the products of multiplying the percent composition by the number of days used and dividing this figure by the total number of days on trial.

TABLE 3. THE CALCULATED NUTRIENT COMPOSITION OF DIETS 231 AND 232, EXPERIMENTS 1 AND 2

Ingredient	Experiment 1 Diet 231	Experiment 1 Diet 232	Experiment 2 Diet 231	Experiment 2 Diet 232
Crude protein (%)	16.00	14.00	16.00	14.00
Arginine (%)	1.060	0.909	1.083	0.916
Lysine (%)	0.791	0.655	0.810	0.658
Methionine (%)	0.266	0.317	0.285	0.350
Methionine + cystine (%)	0.531	0.570	0.540	0.576
Tryptophan (%)	0.203	0.173	0.209	0.175
Glycine (%)	0.709	0.598	0.725	0.603
Histidine (%)	0.375	0.329	0.382	0.333
Leucine (%)	1.477	1.358	1.502	1.378
Isoleucine (%)	0.748	0.641	0.762	0.654
Phenylalanine (%)	0.790	0.697	0.804	0.703
Phenylalanine + tyrosine (%)	1.380	1.235	1.403	1.249
Threonine (%)	0.644	0.570	0.657	0.577
Valine (%)	0.799	0.708	0.810	0.713
Crude fat (%)	5.851	5.996	6.794	5.517
Crude fiber (%)	3.647	3.437	2.968	2.961
Ash (%)	9.137	8.897		
Calcium (%)	2.521	2.509	2.509	2.500
Phosphorus available (%)	0.476	0.468	0.478	0.469
Phosphorus total (%)	0.666	0.647	0.671	0.652
Salt (%)	0.747	0.698	0.549	0.552
Sodium (%)	0.288	0.271	0.307	0.283
Potassium (%)	0.646	0.561	0.630	0.544
Manganese (mg/kg)	36.940	35.700	36.492	35.306
Zinc (mg/kg)	44.947	42.841	43.204	41.618
Iron (mg/kg)	69.583	65.319	70.768	65.994
Copper (mg/kg)	11.108	9.881	8.602	7.996
Cobalt (mg/kg)	0.844	0.844	0.838	0.841
Iodine (mg/kg)	0.630	0.625	0.625	0.622
Magnesium (%)	0.146	0.138	0.144	0.136
Sulfur (mg/kg)	0.002	0.002	0.002	0.002
Xanthophylls (mg/kg)	20.909	22.282	20.856	22.282
Carotene (mg/kg)	3.951	4.054	3.951	4.054
Vitamin A (IU/kg)	7476	7527	7476	7527
Vitamin E (IU/kg)	30.330	30.673	30.330	30.673
Thiamine (mg/kg)	4.061	3.917	4.061	3.917
Riboflavin (mg/kg)	6.053	6.005	6.053	6.005
Niacin (mg/kg)	67.588	67.550	22.264	67.550
Pantothenic acid (mg/kg)	16.294	15.833	16.294	15.833
Choline (mg/kg)	1279	1201	1279	1201
Vitamin B_6 (mg/kg)	6.718	6.896	6.718	6.896
Folacin (mg/kg)	1.625	1.589	0.472	1.589
Biotin (mg/kg)	0.229	0.215	0.229	0.215

TABLE 3 CONTINUED

Ingredient	Experiment 1 Diet 231	Experiment 1 Diet 232	Experiment 2 Diet 231	Experiment 2 Diet 232
Vitamin B_{12} (micrograms/kg)	9.432	9.327	9.432	9.327
Vitamin D_3 (IU/kg)	4400	4400	4400	4400
Vitamin K (mg/kg)	1.100	1.100	1.100	1.100
Metabolizable energy (kilocalories/kilogram)	2948	3007	3078	3067

TABLE 4. STARTER AND GROWER DIETS FED AT SOUTH DAKOTA STATE UNIVERSITY[a]

Ingredients	Starter diet[b] (lb per ton)	Grower diet[c] (lb per ton)
Ground yellow corn	1229	--
Oat hulls	--	550
Ground oats	--	1000
Wheat midds	--	100
Soybean meal (44%)	500	100
Meat scraps	100	40
Alfalfa meal (17%)	40	40
Fish meal	40	20
Dried whey	40	40
Dicalcium phosphate	30	60
Salt	10	10
Limestone	--	30
Methionine	1	--
Vitamin supplement	10	10

[a] Source: South Dakota State University Fact Sheet 136, Feeding Chickens, 1962.

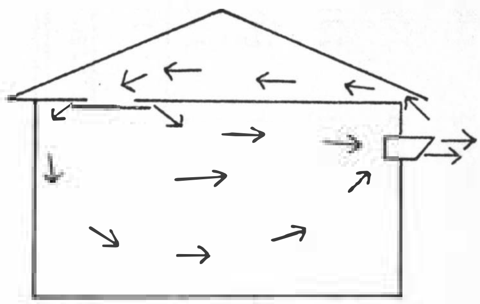
[b] Starter diet contains 20% calculated protein.

[c] Grower diet contains 12% calculated protein.

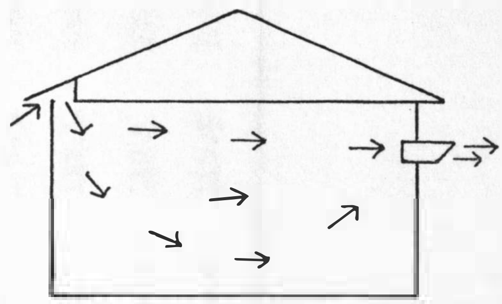
TABLE 5. FLOOR PLAN OF THE ENVIRONMENT HOUSE

TABLE 6. VENTILATION SYSTEMS IN THE ENVIRONMENT HOUSE, THE BROODER HOUSE AND THE CAGE HOUSE[a]

Slot inlet ventilation (used in North and Middle chambers in the environment house, in the brooder house and in the cage house)

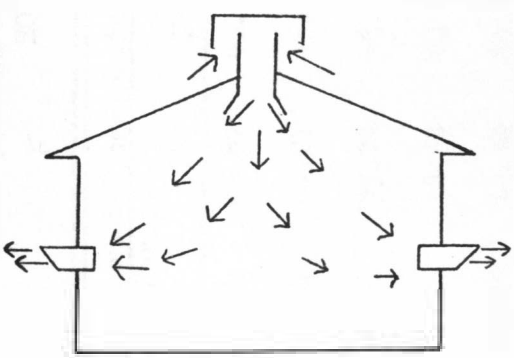


Winter Airflow

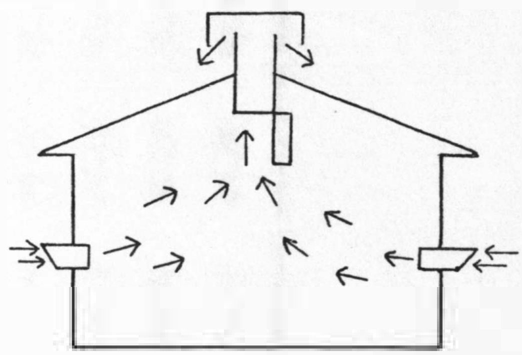


Summer Airflow

Ridge inlet and turn-about fan ventilation (used in South chamber of environment house)



Winter Airflow



Summer Airflow

[a] Plumart, P. E. 1969. Housing the laying hen. S. D. Agr. Exp. Sta. A.S. Series 69-22.

TABLE 7. THE PERFORMANCE OF EACH PEN OF ENVIRONMENT HOUSE LAYERS, EXPERIMENT 1

	Percent hen-day egg production					Grams feed consumed per hen daily				
	Period					Period				
Pen	I	II	III	IV	Overall	I	II	III	IV	Overall
3	43.44	48.70	43.87	41.40	44.43	100.3	103.0	117.1	105.8	107.1
4	48.94	54.59	49.27	46.87	50.00	99.0	119.4	130.3	112.6	116.7
5	33.20	38.61	35.24	45.18	38.50	98.1	113.5	131.7	123.0	118.0
6	29.22	37.74	34.59	40.22	36.01	97.2	121.7	154.4	141.2	131.7
7	46.31	49.96	46.59	45.47	47.15	107.1	118.0	137.1	121.2	122.1
8	44.78	46.08	40.63	39.43	42.54	101.7	114.0	133.5	115.3	117.6
9	36.12	44.34	45.99	41.36	42.48	99.9	108.5	139.4	123.5	119.4
10	27.49	34.33	40.26	40.02	36.26	96.2	117.6	144.4	127.1	123.5
11	40.52	45.70	41.56	41.25	42.42	109.9	117.1	135.3	119.8	121.7
12	44.92	50.43	44.88	43.62	46.06	100.8	110.3	123.5	102.6	109.9

TABLE 7 CONTINUED

Pen	Calculated grams of protein consumed per hen daily					Calculated milligrams of methionine consumed per hen daily				
	Period					Period				
	I	II	III	IV	Overall	I	II	III	IV	Overall
3	14.0	14.4	16.4	14.8	15.0	318	327	371	335	340
4	15.8	19.1	20.8	18.0	18.7	263	318	347	299	310
5	15.7	18.2	21.1	19.7	18.9	261	302	350	327	314
6	13.6	17.0	21.6	19.8	18.4	308	386	489	448	417
7	15.0	16.5	19.2	17.0	17.1	340	374	435	384	387
8	16.3	18.2	21.4	18.4	18.3	270	303	355	307	313
9	16.0	17.4	22.3	19.8	19.1	266	289	371	328	318
10	13.5	16.5	20.2	17.8	17.3	305	373	458	403	391
11	15.4	16.4	18.9	16.8	17.0	348	371	429	380	386
12	16.1	17.6	19.8	16.4	17.6	268	293	328	273	292

TABLE 7 CONTINUED

	Feed efficiency (kg feed per dozen eggs)					Average egg weight in grams				
	Period					Period				
Pen	I	II	III	IV	Overall	I	II	III	IV	Overall
3	3.00	2.55	3.23	3.08	2.96	52.90	56.59	60.82	62.32	59.21
4	2.53	2.65	3.20	2.88	2.84	53.95	57.21	61.27	62.55	59.71
5	4.69	3.85	5.11	3.29	4.19	49.00	52.66	57.74	58.74	55.64
6	5.69	4.13	5.74	4.22	4.88	49.20	53.43	59.02	59.26	56.43
7	2.87	2.87	3.54	3.22	3.15	53.00	56.51	60.77	62.62	59.27
8	2.92	3.01	3.97	3.51	3.39	53.10	56.76	61.05	62.40	59.37
9	4.30	3.17	3.83	3.60	3.67	48.25	50.81	57.23	57.70	54.55
10	5.51	4.95	4.62	3.82	4.65	48.50	52.74	57.58	58.66	55.54
11	3.56	3.15	3.92	3.49	3.53	52.90	56.67	61.72	64.07	60.03
12	2.98	2.67	3.33	2.82	2.95	52.55	55.64	60.58	61.63	58.61

TABLE 7 CONTINUED

Pen	Interior egg quality--Haugh units				Average egg shell thickness in millimeters			
	Period				Period			
	II	III	IV	Overall	II	III	IV	Overall
3	84.03	76.49	75.76	78.76	0.3618	0.3608	0.3596	0.3607
4	84.15	77.63	79.56	80.56	0.3539	0.3653	0.3463	0.3551
5	81.97	76.10	72.39	76.91	0.3646	0.3758	0.3549	0.3638
6	81.63	78.16	75.38	78.40	0.3674	0.3770	0.3576	0.3661
7	84.09	76.79	76.82	79.23	0.3543	0.3601	0.3609	0.3585
8	82.26	76.99	74.41	77.89	0.3630	0.3547	0.3561	0.3579
9	81.17	73.11	75.07	76.87	0.3620	0.3588	0.3441	0.3545
10	81.95	77.56	77.37	79.14	0.3695	0.3692	0.3505	0.3623
11	83.52	76.24	77.67	79.14	0.3583	0.3688	0.3556	0.3609
12	83.60	79.25	76.94	79.93	0.3550	0.3613	0.3499	0.3554

TABLE 7 CONTINUED

	Percent monthly mortality					Average hen weight in kilograms		
	Period					Period		
Pen	I	II	III	IV	Overall	I	III	IV
3	1.74	1.62	1.16	0.92	1.32	1.365	1.940	1.845
4	2.52	1.68	0.24	0.72	1.18	1.388	1.970	1.862
5	1.63	6.10	2.61	0.65	2.85	1.380	2.150	2.077
6	1.96	11.33	0.65	0.00	3.62	1.342	2.070	1.968
7	4.07	2.96	0.25	0.49	1.75	1.403	1.930	1.780
8	4.68	1.68	0.48	0.00	1.44	1.337	1.900	1.737
9	0.64	9.77	0.85	0.43	3.13	1.394	2.080	1.955
10	0.00	15.25	0.00	0.43	4.28	1.412	2.110	2.038
11	1.54	3.34	0.77	0.51	1.54	1.391	1.920	1.766
12	2.82	1.41	0.00	0.00	0.90	1.390	1.910	1.696

TABLE 8. THE PERFORMANCE OF EACH PEN OF ENVIRONMENT HOUSE LAYERS, EXPERIMENT 2

	Percent hen-day egg production				Grams feed consumed per hen daily			
Pen	November	December	February	March	November	December	February	March
1	48.86	68.35	57.73	55.89	87.6	89.0	109.2	104.4
2	42.30	59.36	66.90	62.52	94.4	96.2	108.1	103.5
3	49.00	56.87	66.38	64.51	93.1	98.1	101.3	101.2
4	46.88	54.66	47.99	48.54	102.6	101.7	106.7	99.0
5	46.50	56.52	52.24	44.88	96.3	105.3	106.6	104.4
6	44.54	54.35	62.40	62.96	95.8	111.2	106.5	103.5
7	43.45	53.05	57.68	56.45	96.7	104.9	102.0	98.5
8	41.30	50.76	41.80	43.40	90.3	104.0	104.3	101.2
9	43.12	50.76	44.61	41.73	92.2	101.7	105.0	102.2
10	40.19	53.49	65.73	65.17	94.9	105.3	105.5	100.8
11	49.50	63.60	70.91	69.11	91.3	100.3	109.1	101.7
12	45.83	61.67	63.83	56.22	94.0	106.2	106.6	104.9

TABLE 8 CONTINUED

Pen	Calculated grams of protein consumed per hen daily				Calculated milligrams of methionine consumed per hen daily			
	November	December	February	March	November	December	February	March
1	14.0	14.2	17.5	16.7	233	237	290	278
2	13.2	13.4	15.1	14.5	299	305	343	328
3	14.8	15.6	16.1	16.2	248	261	269	269
4	14.3	14.2	14.9	13.8	325	322	338	314
5	15.3	16.8	17.0	16.7	256	280	284	278
6	13.4	15.5	14.9	14.5	304	352	338	328
7	15.4	16.7	16.3	15.8	257	279	271	262
8	12.6	14.5	14.6	14.2	286	330	331	321
9	14.7	16.2	16.7	16.3	245	270	279	272
10	13.2	14.7	14.7	14.1	301	334	334	320
11	14.6	16.0	17.4	16.3	243	267	290	270
12	13.1	14.8	14.9	14.7	298	337	338	333

TABLE 8 CONTINUED

Pen	Feed efficiency (kg feed per dozen eggs)				Average egg weight in grams			
	November	December	February	March	November	December	February	March
1	2.15	1.56	2.27	2.24	48.60	51.54	56.45	57.20
2	2.68	1.95	1.94	1.99	49.07	52.71	56.75	57.30
3	2.28	2.07	1.83	1.88	47.33	50.70	54.80	55.95
4	2.62	2.23	2.61	2.44	47.90	51.69	56.20	57.25
5	2.48	2.23	2.45	2.80	48.52	52.42	56.45	58.00
6	2.58	2.46	2.05	1.97	48.04	51.74	56.30	58.15
7	2.67	2.37	2.14	2.09	48.05	51.74	55.45	56.75
8	2.63	2.46	3.00	2.80	47.65	51.58	56.35	56.85
9	2.56	2.40	2.83	2.94	47.15	50.55	55.35	56.25
10	2.84	2.37	1.94	1.85	46.72	51.67	56.05	56.55
11	2.19	1.90	1.85	1.76	48.23	50.97	55.25	56.05
12	2.46	2.07	2.01	2.24	47.79	51.13	56.20	56.95

TABLE 8 CONTINUED

Pen	Interior egg quality--Haugh units				Average egg shell thickness in millimeters		
	November	December	February	March	November	February	March
1	86.76	84.66	69.89	73.20	0.3252	0.3444	0.3328
2	87.31	82.24	76.25	73.46	0.3256	0.3556	0.3404
3	85.29	82.13	67.48	73.47	0.3340	0.3800	0.3516
4	87.54	76.92	64.96	71.34	0.3264	0.3460	0.3412
5	85.19	75.61	66.19	72.41	0.3444	0.3436	0.3268
6	87.74	76.37	67.50	63.93	0.3328	0.3584	0.3464
7	85.19	77.56	67.44	70.15	0.3328	0.3672	0.3432
8	86.44	77.44	70.51	73.20	0.3372	0.3540	0.3400
9	85.71	76.04	69.51	73.06	0.3364	0.3432	0.3388
10	86.55	75.38	69.00	72.82	0.3436	0.3500	0.3336
11	85.58	75.69	66.75	68.91	0.3288	0.3628	0.3296
12	84.96	74.47	68.58	70.02	0.3336	0.3492	0.3320

TABLE 8 CONTINUED

Pen	Percent monthly mortality				Average hen weight in kilograms		
	November	December	February	March	November 1	December 20	March 10
1	0.71	1.43	1.43	0.00	1.282	1.649	1.753
2	0.71	1.43	0.00	0.00	1.308	1.701	1.724
3	0.00	1.43	0.71	0.00	1.266	1.637	1.672
4	0.71	0.71	0.71	0.71	1.279	1.632	1.696
5	0.00	0.00	0.71	0.71	1.282	1.662	1.746
6	1.43	1.43	0.71	0.00	1.269	1.613	1.713
7	0.00	0.71	2.86	1.43	1.286	1.664	1.679
8	0.00	1.43	0.00	3.57	1.276	1.624	1.739
9	2.14	0.00	0.71	1.43	1.269	1.645	1.705
10	0.00	0.71	0.71	0.71	1.273	1.639	1.702
11	2.14	1.43	0.71	1.43	1.286	1.629	1.711
12	3.57	0.00	0.00	0.71	1.266	1.636	1.711